University of Zambia

School of Natural Sciences

2015 Full Year Courses Exams

1. BIO 1412 -   Molecular biology and genetics
2. BIO 2812 -   Diversity of animals
3. BIO 3212 -   Insect taxonomy, classification and identification
4. C 2615   -   Basic physics chemistry
5. CHE 1000 -   Introduction to Chemistry
6. CHE 2112 -   Introductory biochemistry
7. CHE 2522 -   Functional group and arena chemistry
8. CHE 3422-   Organometalics and Inorganic reaction Mechanism
9. CHE 3522 -   Polyfuntional compounds, Molecular rearrangements and organic Synthesis
10. CHE 4422
11. CHE 4522 -   Physical organic chemistry and natural products Chemistry
12. CHE 4811-   Inorganic Industrial Chemistry
13. CS 3120   -   Digital Electronics
14. CSC 2000   -   Computer Programming
15. CSC 3402   -Introduction to artificial intelligence
16. CSC 3612   -IT project Management
17. CSC 4505 - Graphic and Visual Computing
18. CSC 4630 -Advanced software engineering
19. CSC 4722 -Distributed systems
20. GEO 111 –Introduction to Human Geography
21. GES1310 - Introduction to Geography
22. GES 2130 - The Geography of Africa with special reference to Zambia.
23. GES 2422 - Statically Methods in Geography
24. GES 3262 - Bio-Geography
25. GES 3330 - Environment and Development.
26. GES 3342 - Environmental Planning and Management

27. GES 3361 - Population, Culture and Environment

28. GES 4372 - Tourism, Environment and Development

29. GES 6431 - Planning law and Governance

30. M 2100 - Analytical geometry and calculus

31. MAT 1110 - Foundation Mathematics and Statistics for Social Sciences

32. MAT 1100 - Foundational Mathematics.

33. MAT 2110

34. MAT 2200 - Linear Algebra

35 MAT 2602 - introduction to Statistics II

36. MAT 3110 - Engineering Mathematics II

37 .MAT 3300 - Real Analysis

38 .MAT 4212 - Module and Field Theory

39 .MSE 3060 - Chemistry Teaching and Methods

40. MSE 9060 - Advanced chemistry teaching methods

41 PHY 1010 - Introductory Physics

42. PHY 2112 - Magnetism in Matter and Atomic Physics

43. PHY 2522 - Analytical Mechanics and Special Theory of Relativity

44 PHY 2712 - Optics

45 PHY 4132 - Theoretical Nuclear Physics

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 1412: MOLECULAR BIOLOGY AND GENETICS
THEORY PAPER **(100 MULTIPLE CHOICE)**

TIME: THREE HOURS

INSTRUCTIONS:

1. **You are not allowed to communicate with any other candidate (Cell phones are not allowed in the examination hall).**

2. If you have any question, raise your hand and wait for the invigilator to attend to you

3. Use the answer sheet provided to answer the questions.

4. Answer **ALL** questions.

5. Use ink to record your answers on the answer sheet.

6. Cross out the wrong and the write the correct one by the side.

7. Choose the best answer from the five options given for each question.

8. The option 'I do not know 'carries 0 marks.

9. Each correct answer carries 4 marks.

10. Each wrong answer carries negative one (-1) mark.

11. A blank space carries negative one (-1) mark.

12. Handover the question paper and answer sheet to the invigilator at the end of examination.

13. Tables required for some questions are given on the last page of the examination paper.

1. Which one of the following statements is **false** about replication of DNA?
    1. Daughter double helices are generated behind a moving replication fork.
    2. A molecule of DNA is duplicated ahead of a replication fork.
    3. The initial step in unwinding DNA double helix is accomplished by the initiation complex.
    4. The positions at which the DNA helix is first opened are called replication origins.
    5. Positions on DNA that are rich in adenine and thymine base pairs are typically found at replication origins.
    6. I do not know.

2. Which of the following statements is **not correct**?
    1. The genome of *E. coli* is contained in a single circular DNA molecule.
    2. Bacterial chromosomes have a single origin of replication.
    3. Eukaryotic chromosomes contain multiple origins of replication.
    4. In eukaryotic cells DNA replication happens twice during meiosis.
    5. The cell grows continuously up to the G_2 phase of a cell cycle.
    6. I do not know.

3. Identify the **correct** statement from the following:
    1. Four genes are responsible for the production of a nucleosome in a cell.
    2. Synthesis of the lagging strand at a replication fork must occur continuously.
    3. The fundamental chromatin packaging unit is called a nucleosome.
    4. Ester bonds must break between base pairs for replication of DNA to begin.
    5. Semi conservative replication results in two single stranded daughter DNA molecules.
    6. I do not know.

4. DNA ligase catalyses the formation of ... in the lagging strand.
    1. phosphodiester linkages
    2. hydrogen bonds
    3. Okazaki fragments
    4. RNA primers
    5. ionic bonds
    6. I do not know.

5. Which of the following statements is **not correct**?
    1. An Okazaki fragment always begins with a ribonucleic acid primer.
    2. The deoxyribonucleic leading strand is polymerised in the 3^l to 5^l direction during replication.
    3. The separation of base pairs at the replication fork is achieved by the enzyme helicase.
    4. To every cytosine on the DNA template strand is added a complementary guanine on the new strand.
    5. DNA polymerase catalyses synthesis reactions during replication.
    6. I do not know.

6. The rate of DNA synthesis can be specifically estimated by the use of radio active ...
   1. Adenine.
   2. Cytosine.
   3. Thymine.
   4. Uracil.
   5. Guanine.
   6. I do not know.

7. Okazaki fragments are synthesized on ...
   1. the leading strand toward the replication fork.
   2. the lagging strand toward the replication fork.
   3. both strands in both directions.
   4. the leading strand away from the replication fork.
   5. the lagging strand away from the replication fork.
   6. I do not know.

8. An actively dividing bacterial culture is grown in a medium containing radioactive adenine (A*). After all the bacterial adenine is labelled, the bacteria are transferred to a medium containing nonradioactive adenine (A). Following one round of bacterial replication in the nonradioactive medium, the DNA is analysed. Which of the following sequences could represent this DNA?
   1. A* A* T T G A* T C
      T T A A C T A G
   2. A* A T T G A* T C
      T T A* A* C T A G
   3. A A T T G A T C
      T T A A C T A G
   4. A* A* T T G A* T C
      T* T* A A C T* A G
   5. A A T T G A T C
      T T A A* C T AG
   6. I do not know.

9. The chemical structure of 5¹ cap of eukaryotic mRNA is ... .
   1. 5-methyl adenosine triphosphate.
   2. 7-hydroxy guanosine triphosphate.
   3. 5-methyl guanosine triphosphate.
   4. 7-methyl guanosine triphosphate.
   5. 5, 7-di methyl adenosine triphosphate.
   6. I do not know.

10. Transcription of a gene in a human cell ...
   1. always begins at an AUG codon.
   2. does not require unwinding of DNA.
   3. always reads the template in the $3^1 \rightarrow 5^1$ direction.
   4. requires a primer.
   5. involves the whole chromosome.
   6. I do not know.

11. The enzyme used to catalyse the synthesis of mRNA is ...
   1. RNA primase.
   2. helicase.
   3. RNA ligase.
   4. DNA polymerase.
   5. RNA polymerase.
   6. I do not know.

12. The wobble hypothesis involves ...
   1. tRNA only.
   2. mRNA only.
   3. rRNA only.
   4. both rRNA and tRNA
   5. both tRNA and mRNA
   6. I do not know.

13. The genetic code is considered degenerate because ...
   1. it is universal.
   2. it is applied in a few organisms.
   3. more than one nucleotide triplet codes for the same amino acid.
   4. it has limited applications.
   5. DNA can be denatured.
   6. I do not know.

14. The enzyme involved in amino acid activation is ...
   1. aminoacyl tRNA synthetase.
   2. aminoacyl mRNA synthetase.
   3. ATP synthetase.
   4. aminoacyl rRNA synthetase.
   5. a helicase.
   6. I do not know.

15. Which of the following statements is **not correct**?
   1. The ribosome reads mRNA in the $5' \rightarrow 3'$ direction during elongation.
   2. The peptidyl site is aligned with the codon AUG at the $3'$ end of mRNA.
   3. tRNA is oriented in the opposite direction to mRNA during elongation.
   4. The ribosomal subunits are normally bound to each other during elongation.
   5. A peptide bond forms between amino acids on tRNAs in the 'P' and 'A' sites.
   6. I do not know.

16. Which of the following statements is **correct** about the process of transcription?
   1. RNA polymerase reads the template (antisense) strand $3'$ to $5'$.
   2. RNA polymerase reads the non-template (sense) strand $3'$ to $5'$.
   3. RNA polymerase reads the template (antisense) strand $5'$ to $3'$.
   4. RNA polymerase reads the non-template (sense) strand $5'$ to $3'$.
   5. Messenger RNA transcript has the same nucleotide sequence as the template DNA strand.
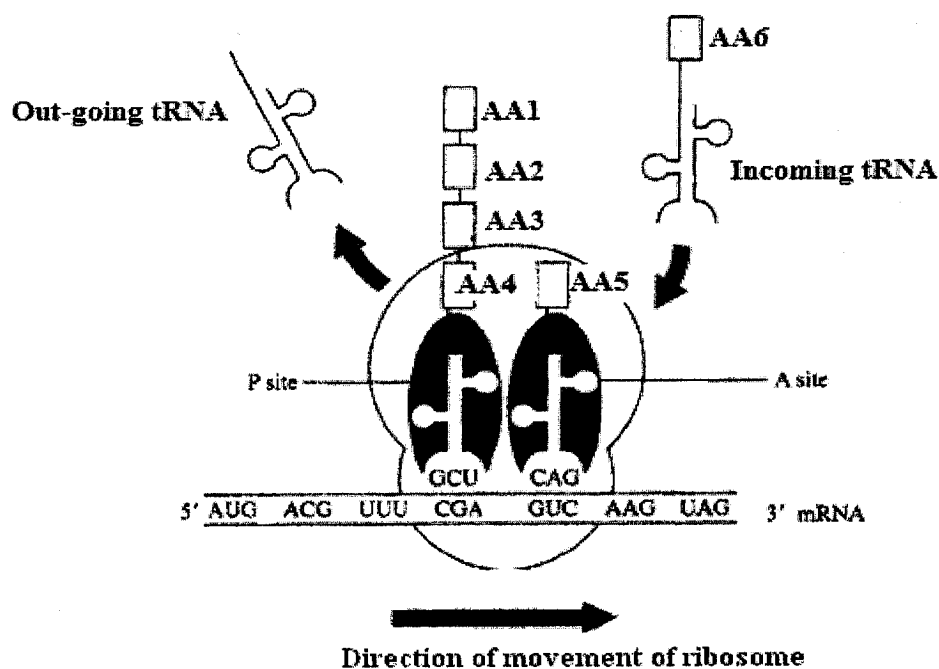   6. I do not know

17. Which of the following statements is **not correct**?
    1. Capping facilitates attachment of mRNA to the ribosome.
    2. mRNA molecules are polyadenylated at the 3' end of the molecule.
    3. The mRNA transcript is interrupted by non-coding parts.
    4. Capping provides stability to mRNAs.
    5. Polyadenylation plays an important role in the stability of DNA
    6. I do not know.

18. All of the following materials are required for translation, except...
    1. t-RNA of several kinds.
    2. elongation factors and guanosine triphosphate.
    3. amino acids and mRNA.
    4. initiation factors.
    5. RNA polymerase.
    6. I do not know.

19. During protein synthesis, the newly synthesised polypeptide is covalently bound to...
    1. the large rRNA sub unit.
    2. the small rRNA sub unit.
    3. the 3' end of tRNA.
    4. the 5' end of mRNA.
    5. the aminoacyl synthetase enzyme.
    6. I do not know.

20. Transfer RNA is synthesised...
    1. in the nucleolus.
    2. in the cytoplasm.
    3. in the ribosome.
    4. on a DNA template.
    5. from mRNA.
    6. I do not know.

21. In an analysis of a DNA sample, which result would be consistent with the base pairing rule?
    1. A + C = G + T
    2. U + G = A + T
    3. A + G = C + U
    4. A + G = C + T
    5. A + T = G + C
    6. I do not know.

22. The promoter region on DNA plays a role in ...
    1. DNA replication.
    2. Mitosis.
    3. Meiosis.
    4. gene regulation.
    5. gene expression.
    6. I do not know.

23. ...at the metaphase plate during mitosis.
    1. Chromatin threads are present
    2. Cytoplasmic organelles duplicate
    3. Single chromosomes are present
    4. Homologous chromosomes synapse
    5. Pairs of duplicated chromosomes are present
    6. I do not know.

24. Which of the following offspring proportions would be expected in the cross RrTt x rr tt where allele R (red fruit) is dominant over allele r (yellow fruit) and allele T (tall plant) is dominant over allele t (short plant)?
    1. All the offspring will be tall with red fruit.
    2. ¾ will be tall with red fruit.
    3. ½ will be tall with red fruit.
    4. ¼ will be tall with red fruit.
    5. None of the above is correct.
    6. I do not know.

25. Elongation of the leading strand during DNA replication...
    1. occurs in the 3` → 5` direction.
    2. produces Okazaki fragments.
    3. depends on the action of DNA polymerase.
    4. progresses away from the replication fork.
    5. does not require a template strand.
    6. I do not know.

26. Using the genetic code in Table 1, identify a possible sequence of nucleotides in the DNA template strand given below for an mRNA coding for the polypeptide sequence: Phe-Trp-Lys.
    1. UUU GGG AAA
    2. AAA ACC TTT
    3. GAA CCC CTT
    4. CTT CGG GAA
    5. AAA CCC UUU`
    6. I do not know

27. The phenomenon known as wobble hypothesis refers to the ...
    1. ability of a tRNA to match with codons that may differ in the third base.
    2. movement of a tRNA from the A site to the P site.
    3. ability of DNA to make more than one type of RNA.
    4. shifting of the reading frame through the translocation of ribosome during translation.
    5. movement of several ribosomes along the same mRNA.
    6. I do not know.

28. In order for a gene to be transcribed the appropriate enzyme must have an access to the DNA helix and be able to bind to the gene's ...
   1. operator.
   2. regulator.
   3. promoter.
   4. repressor.
   5. activator.
   6. I do not know.

29. Where along the chromosome is DNA replication initiated?
   1. At a start codon.
   2. At any position.
   3. At exons.
   4. At introns.
   5. At a replication origin.
   6. I do not know.

30. Which one of the following is an example of a possible step in the post-transcription of DNA?
   1. The removal of exons.
   2. The removal of introns.
   3. The folding of DNA to form a double helix.
   4. The binding of transcription factors to a promoter site.
   5. Capping of the primary mRNA transcript at the 3' end.
   6. I do not know.

31. The characteristics of the genetic material include ...
   1. storage of hereditary information.
   2. ability to replicate.
   3. generation of genetic variation.
   4. expression of information.
   5. all of the above.
   6. I do not know

32. The central dogma of molecular biology states that ...
   1. DNA is a template for DNA replication.
   2. DNA is a template for protein synthesis.
   3. translation takes place before transcription.
   4. RNA is a template for DNA replication.
   5. All of the above are correct.
   6. I do not know.

33. Interphase of the cell cycle includes...
   1. stages G_1, G_2 and S in that order.
   2. stages of prophase, metaphase, anaphase, and telophase.
   3. stages G_1, S and G_2 in the given order.
   4. stages S, G_1 and G_2 in that order.
   5. stages G_1 and G_2 only.
   6. I do not know.

40. ...joins adjacent Okazaki fragments from which ... have been removed.
    1. DNA ligase; RNA primers
    2. DNA polymerase; RNA primers
    3. Primase; enzyme primers
    4. Helicase; hydrogen bonds
    5. Topoisomerase; DNA coils
    6. I do not know.

41. The first three prokaryotic DNA nucleotides to be transcribed are most likely to be...
    1. AUG
    2. UAC
    3. ATG
    4. TAC
    5. AGT
    6. I do not know.

42. Choose the **true** statement.
    1. A prokaryotic ribosome has an amino acid attachment site on its 3' end.
    2. Prokaryotic tRNA has four arms.
    3. Prokaryotic tRNA has two arms.
    4. The anticodon is located on mRNA.
    5. Prokaryotic tRNA has three arms.
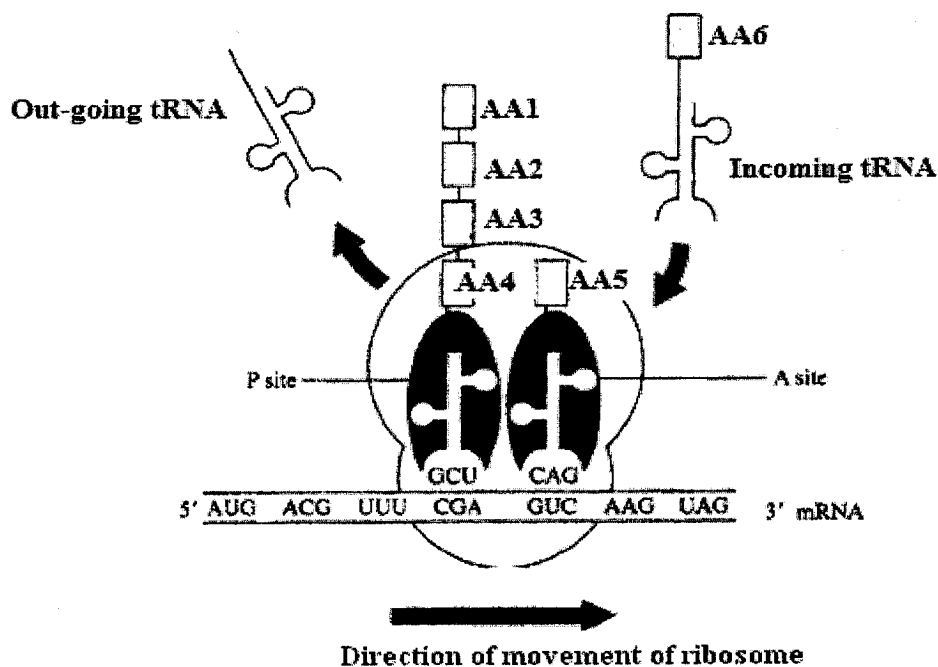   6. I do not know.

For questions **43-45** that follow, study the figure below which shows the process of translation in a prokaryotic cell. The genetic code is given in Table 1.

Direction of movement of ribosome

AA1 = amino acid 1; AA2 = amino acid 2; AA3 = amino acid 3; AA4 = amino acid 4; AA5 = amino acid 5; AA6 = amino acid 6

9

40. ...joins adjacent Okazaki fragments from which ... have been removed.
    1. DNA ligase; RNA primers
    2. DNA polymerase; RNA primers
    3. Primase; enzyme primers
    4. Helicase; hydrogen bonds
    5. Topoisomerase; DNA coils
    6. I do not know.

41. The first three prokaryotic DNA nucleotides to be transcribed are most likely to be...
    1. AUG
    2. UAC
    3. ATG
    4. TAC
    5. AGT
    6. I do not know.

42. Choose the **true** statement.
    1. A prokaryotic ribosome has an amino acid attachment site on its 3' end.
    2. Prokaryotic tRNA has four arms.
    3. Prokaryotic tRNA has two arms.
    4. The anticodon is located on mRNA.
    5. Prokaryotic tRNA has three arms.
    6. I do not know.

For questions **43-45** that follow, study the figure below which shows the process of translation in a prokaryotic cell. The genetic code is given in Table 1.

Direction of movement of ribosome

AA1 = amino acid 1; AA2 = amino acid 2; AA3 = amino acid 3; AA4 = amino acid 4; AA5 = amino acid 5; AA6 = amino acid 6

43. Determine the anti-codons of outgoing tRNA and the incoming tRNA.
    1. UUC and UAC
    2. AAC and UUU
    3. UAC and AAG
    4. AUG and AAG
    5. AAA and UUC
    6. I do not know.

44. Determine the amino acids AA4, AA1 and AA6.
    1. AA4 = Methionine; AA1 = Arginine; AA6 = Lysine
    2. AA4 = Methionine; AA1 = Lysine; AA6 = Histidine
    3. AA4 = Arginine; AA1 = Methionine; AA6 = Lysine
    4. AA4 = Arginine; AA1 = Lysine; AA6 = Methionine
    5. AA4 = Methionine; AA1 = Lysine; AA6 = Valine
    6. I do not know.

45. Determine the number of amino acids in this polypeptide when it is completed.
    1. 3
    2. 4
    3. 5
    4. 6
    5. 7
    6. I do not know.

46. During initiation of prokaryotic translation f-methionine binds to the...
    1. 50S ribosomal subunit.
    2. 80S ribosomal subunit.
    3. 30S ribosomal subunit.
    4. 60S ribosome.
    5. 70S ribosome.
    6. I do not know.

47. Choose the statement which is **false** about gene regulation.
    1. It involves switching on and off the process of transcription.
    2. It is switched on by the inducer substance.
    3. The rate of transcription can be either increased or decreased.
    4. It involves a single gene called an operon.
    5. It can be switched off by the repressor substance.
    6. I do not know.

48. A gene is ...
    1. a group of introns.
    2. an alternative term for a chromosome.
    3. a combination of tRNA, mRNA and rRNA in a segment of DNA.
    4. a sequence of RNA nucleotides responsible for expression of one complete protein.
    5. a sequence of DNA nucleotides responsible for expression of a polypeptide.
    6. I do not know.

49. Choose the correct statement.
    1. RNA polymerase binds to the operator.
    2. The promoter is responsible for the production of the repressor.
    3. *Lac* A gene is responsible for the production of acetylase.
    4. Lactose is broken down into α-glucose and α-galactose.
    5. *Lac* Y gene is responsible for the production of permease.
    6. I do not know.

50. The generation time during the cell cycle is the ...
    1. length of time it takes to generate new DNA .
    2. length of time it takes to generate new chromosomes.
    3. duration of the S-phase of interphase.
    4. duration of the mitotic phase.
    5. time taken from interphase to cytokinesis.
    6. I do not know.

51. Choose the statement which is **not true** about the functions of mitosis.
    1. It is involved in cell growth and development.
    2. It brings about genetic variation.
    3. It is important in asexual reproduction.
    4. It produces identical cells.
    5. It is responsible for tissue regeneration.
    6. I do not know.

52. In a dihybrid cross between two heterozygous parents, the probability of obtaining an offspring that is homozygous recessive for both traits would be approximately ...
    1. 0.19
    2. 0.56
    3. 0.75
    4. 0.25
    5. 0.06
    6. I do not know

53. One of the earliest events that distinguishes meiosis from mitosis occurs in prophase 1 and involves...
    1. loss of the nuclear envelope.
    2. disappearance of the nucleolus.
    3. pairing of homologous chromosomes.
    4. condensation of chromosomes.
    5. the formation of spindle fibres.
    6. I do not know.

54. To determine whether an animal is dominant homozygous or heterozygous it is crossed with an animal that is ...
    1. heterozygous dominant.
    2. heterozygous recessive.
    3. homozygous recessive.
    4. homozygous dominant.
    5. Both 3 and 4 above.
    6. I do not know

For questions **55-57** use the flowing information: A cross was carried out between flies with normal long wings and flies with vestigial wings. In the F_1 generation all flies had long wings. In the F_2 generation, the following results were obtained:

Long winged flies   792
Vestigial winged flies   208

Carry out a chi-squared test on these results Table 2 of critical χ^2.

55. The calculated chi-square (χ^2) value is ...
1. 2.5
2. 7.5
3. 4.2
4. 7.1
5. 9.4
6. I do not know

56. The tabulated (critical) χ^2 value is question 55 above is...
1. 2.4
2. 0.5
3. 6.6
4. 3.8
5. 1.4
6. I do not know

57. Use the results of the test in questions 55 and 56 above to make your conclusion.
1. The results agree with the Mendelian F_2 monohybrid ratio.
2. The results agree with the Mendelian F_1 monohybrid ratio.
3. The results do not agree with the Mendelian F_1 monohybrid ratio.
4. The results do not agree with the Mendelian F_2 monohybrid ratio.
5. The results agree with the Mendelian F_1 dihybrid ratio.
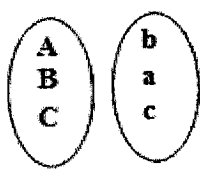6. I do not know.

58. During cell division, centromeres ... and release their chromatids at the beginning of ...
1. duplicate, interphase
2. duplicate, telophase
3. disintegrate, telophase
4. separate, prophase
5. divide, anaphase
6. I do not know.

59. DNA replication in *E. coli* is ...
1. semi-conservative and unidirectional.
2. conservative and unidirectional.
3. semi-conservative and bidirectional.
4. conservative and bidirectional.
5. conservative and multidirectional.
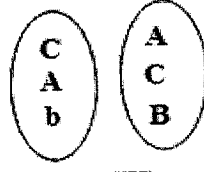6. I do not know.

60. Given below is a set of four pairs of chromosomes. Choose the pair(s) which best illustrate(s) the chromosomal theory of inheritance.
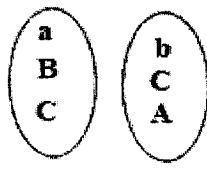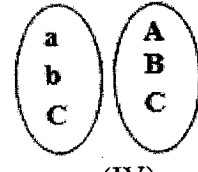

(I)   (II)   (III)   (IV)

1. Pair I
2. Pair II
3. Pair II
4. Pair IV
5. Pairs I and IV
6. I do not know

61. How many different genotypes exist among F_2 offspring in a Mendelian dihybrid cross?
   1. 1
   2. 3
   3. 4
   4. 9
   5. 16
   6. I do not know

62. Why must the lagging strand of DNA be replicated in short pieces?
   1. Because the two strands of DNA are anti-parallel.
   2. Because DNA polymerase III synthesises only in 5' to 3' direction .
   3. Because only one strand can serve as a template for continuous DNA synthesis.
   4. 1 and 2 above are correct.
   5. All of the above are correct.
   6. I do not know

63. Describe the action of the *lac* operon when bacteria cells are grown in a solution with a high concentration of glucose in the absence of lactose.
   1. The *lac* operon will be activated.
   2. The *lac* operon will be switched off.
   3. RNA polymerase will bind at the promoter site of the *lac* operon.
   4. the structural genes are transcribed so that the cells can have energy.
   5. The repressor protein fails to attach to the operator site.
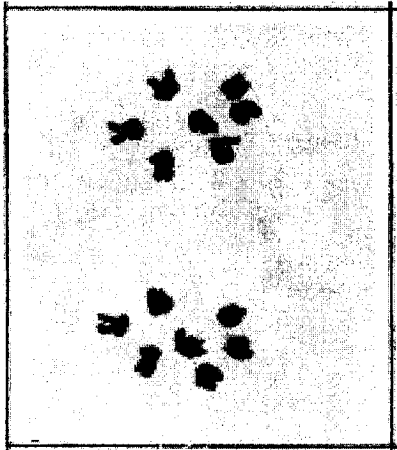   6. I do not know.

64. Describe the action of the *lac* operon when bacterial cells are grown in the absence of glucose and presence of lactose.
   1. The *lac* operon will be inactivated.
   2. The repressor protein binds to lactose.
   3. RNA polymerase will bind at the operator site of the *lac* operon.
   4. The three structural genes will not be transcribed.
   5. RNA polymerase will attach to the promoter site.
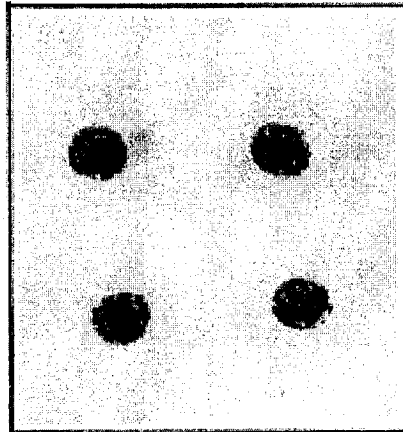   6. I do not know.

65. Which gene in an operon is **incorrectly** matched with its function?
    1. promoter --- binding site for RNA polymerase
    2. regulator --- binds to the repressor protein
    3. structural genes --- make mRNA by transcription
    4. operator--- binding site for repressor
    5. inducer --- changes the shape of the repressor protein
    6. I do not know.

66. During translation, the amino acid in the P-site detaches from the transfer RNA molecule and attaches to the end of a growing polypeptide chain when ...
    1. the ribosomal RNA anticodon binds to the messenger RNA codon.
    2. the transfer RNA anticodon binds to the messenger RNA codon.
    3. a stop codon is encountered.
    4. the outgoing tRNA enters the P-site of the ribosome.
    5. the incoming tRNA enters the P-site of the ribosome.
    6. I do not know.

67. What is the protein molecule coded for by the segment of mRNA given below?
    CUCAAGUGCUUC
    1. SerTyrArgGly
    2. ValAspProHis
    3. LeuLysCysPhe
    4. ProGluLeuVal
    5. GluPheSerLeu
    6. I do not know.

68. Which of the following would represent the strand of DNA from which the mRNA strand **CUCAAGUGCUUC** was made?
    1. CUCAAGUGCUUC
    2. GAGUUCACGAAG
    3. GAGTTCACGAAG
    4. AGACCTGTAGGA
    5. GAGTTCACGUUG
    6. I do not know

69. Which of the following statements is **wrong**?
    1. A centrosome is a component of centrioles.
    2. Each chromosome has two chromatids at metaphase of mitosis.
    3. Each chromatid becomes a chromosome at anaphase of mitosis.
    4. Mitosis produces two identical daughter cells.
    5. All cells have an even diploid number of chromosomes.
    6. I do not know.

70. A test cross was carried out by Mendel. Which of the following offspring results showed that the parental dominant tall plants were actually heterozygous?
    1. TT, TT, Tt, tt.
    2. Tt, Tt, Tt, Tt.
    3. tt, tt, tt, tt.
    4. TT, TT, TT, TT.
    5. Tt, tt, tt, Tt.
    6. I do not know.

82. Choose the RNA type(s) that is(are) translated into a polypeptide.
    1. tRNA
    2. mRNA
    3. rRNA
    4. tRNA and mRNA
    5. tRNA and rRNA
    6. I do not know

83. If the complementary DNA sequence to template DNA sequence is GATTACTA, the resulting mRNA sequence is ...
    1. GAUUACUA .
    2. CUAAUCAU.
    3. TAGTAATC.
    4. ATCATTAG.
    5. GATTACTA.
    6. I do not know.

84. The *Lac* operon is a group of genes involved in the metabolism of ...
    1. galactose.
    2. lac.
    3. glucose.
    4. lactase.
    5. β-galactoside.
    6. I do not know.

85. Chromosomes are best observable at the stage of ...
    1. interphase.
    2. prophase.
    3. metaphase.
    4. anaphase.
    5. telophase.
    6. I do not know.

86. When crossing over is complete at prophase I ...
    1. non-sister chromatids would have exchanged segments of their DNA.
    2. sister chromatids are aligned at the equatorial plate.
    3. non-sister chromatids are held together by a common centromere.
    4. sister chromatids drift away from each other.
    5. sister and non-sister chromatids duplicate.
    6. I do not know.

For questions **87- 90** study diagrams of a eukaryotic cell undergoing division as shown below. A-E represent different stages of the same undergoing division.
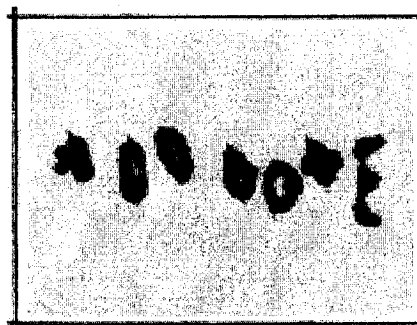

A

B

C

D

E

87. The cell under investigation ....
    1. could be from a bacterial species.
    2. is undergoing mitosis.
    3. is undergoing meiosis.
    4. has 7 chromosomes.
    5. is in interphase.
    6. I do not know.

88. Identify the diagram representing anaphase II.
    1. A
    2. B.
    3. C
    4. D
    5. E
    6. I do not know.

89. Identify the diagram representing metaphase II.
    1. A
    2. B.
    3. C
    4. D
    5. E
    6. I do not know.

90. Identify the diagram representing telophase I.
    1. A
    2. B.
    3. C
    4. D
    5. E
    6. I do not know.

For questions **91-93** use the following information: A couple has just had the first of what they hope will be several children. Both wife and husband are brown eyed with free earlobes, but their first child is blue eyed with attached earlobes.

91.Identifiy the possible genotypic ratio of the F_1 generation of this couple.
    1. 4BBAA : 2BBaa : 2bbAA : 2bbaa : 1BbAA : 1Bbaa : 1BBAa : 1bbAa : 2BbAa
    2. 2BBAA : 2BBaa : 1bbAA : 1bbaa : 2BbAA : 2Bbaa : 2BBAa : 2bbAa : 2BbAa
    3. 1BBAA : 1BBaa : 1bbAA : 1bbaa : 2BbAA : 2Bbaa : 2BBAa : 2bbAa : 4BbAa
    4. 1BBaa : 1BBaa : 1BBAA : 1bbaa : 2BbAA : 2Bbaa : 2BbAa : 2bbAa : 4BbAa
    5. 1BBAA : 1BBaa : 1bbAA : 1bbaa : 1BbAA : 1Bbaa : 1BBAa : 1bbAa : 1BbAa
    6. I do not know.

92. Identify the genotypes of the parents.
    1. Mother (BBAA): Father (BBAA)
    2. Mother (bbAA): Father (BBaa)
    3. Mother (BbAa): Father (BBAA)
    4. Mother (BBAA): Father (BbAa)
    5. Mother (BbAa): Father (BbAa)
    6. I do not know.

93. What proportion of the children would have the same genotype as the mother?
    1. 0.75
    2. 0.25
    3. 0.50
    4. 0.13
    5. 1.00
    6. I do not know.

94. In anaphase I ...
1. recombinant chromatids are pulled apart.
2. centromeres are replicated.
3. chromosomes exchange portions of DNA.
4. sister chromatids are separated.
5. chromatids replicate.
6. I do not know.

95. Which of the following is a dihybrid cross?
1. Wwww x WwSs
2. WwSS x SSSs
3. WwSs x Wwws
4. WWss x wwSS
5. WwSs
6. I do not know.

96. Ribosomal RNA ...
1. is a site for protein synthesis.
2. is used to transport amino acids.
3. carries the genetic code for protein synthesis.
4. is involved in DNA transcription.
5. is involved in the translation of mRNA into DNA.
6. I do not know.

97. The process of ... results in the production of mature mRNA.
1. RNA replication
2. RNA translocation
3. RNA elongation
4. RNA splicing
5. RNA priming
6. I do not know.

98. In a process called ... a tRNA is ejected from the ribosome.
1. amino acid activation
2. initiation of translation
3. ribosomal translocation
4. DNA transcription
5. DNA replication
6. I do not know.

99. In the process of translation...
1. mRNA is formed with a nucleotide sequence complementary to that of DNA.
2. a polypeptide molecule is formed according to rRNA nucleotide sequence.
3. tRNA nucleotide sequence is used to synthesise mRNA.
4. a polypeptide molecule is formed according to the nucleotide sequence in mRNA.
5. mRNA reads the codons on tRNA to synthesise a protein.
6. I do not know.

100. Transfer RNA is ...
1. double stranded throughout its length.
2. made up of two antiparallel strands.
3. longer than DNA molecule.
4. single stranded and has an adenine base at the 3' end.
5. a complementary copy of mRNA.
6. I do not know.

Table 1: The genetic code

		Second base				
		U	C	A	G	
F i r s t b a s e	U	UUU } PHE UUC UUA } LEU UUG	UCU UCC } SER UCA UCG	UAU } TYR UAC UAA } STOP UAG	UGU } CYS UGC UGA } STOP UGG } TRP	U C A G
	C	CUU CUC } LEU CUA CUG	CCU CCC } PRO CCA CCG	CAU } HIS CAC CAA } GLN CAG	CGU CGC } ARG CGA CGG	U C A G
	A	AUU AUC } ILE AUA AUG } MET or START	ACU ACC } THR ACA ACG	AAU } ASN AAC AAA } LYS AAG	AGU } SER AGC AGA } ARG AGG	U C A G
	G	GUU GUC } VAL GUA GUG	GCU GCC } ALA GCA GCG	GAU } ASP GAC GAA } GLU GAG	GGU GGC } GLY GGA GGG	U C A G

The rightmost column is labeled: Third base

Table 2: Critical values for the χ^2

		PROBABILITY										
		0.01	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
DEGREES OF FREEDOM	1	6.6	3.8	2.7	1.6	1.1	0.71	0.45	0.27	0.15	0.064	0.016
	2	9.2	6.0	4.6	3.2	2.4	1.83	1.39	1.02	0.71	0.446	0.211
	3	11.3	7.8	6.3	4.6	3.7	2.95	2.37	1.87	1.42	1.005	0.584
	4	13.3	9.5	7.8	6.0	4.9	4.04	3.36	2.75	2.19	1.649	1.064
	5	15.1	11.1	9.2	7.3	6.1	5.13	4.35	3.66	3.00	2.343	1.610
	6	16.8	12.6	10.6	8.6	7.2	6.21	5.35	4.57	3.83	3.070	2.204
	7	18.5	14.1	12.0	9.8	8.4	7.28	6.35	5.49	4.67	3.822	2.833
	8	20.1	15.5	13.4	11.0	9.5	8.35	7.34	6.42	5.53	4.594	3.490
	9	21.7	16.9	14.7	12.2	10.7	9.41	8.34	7.36	6.39	5.380	4.168

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 2812: DIVERSITY OF ANIMALS
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS: **TWO** FROM EACH SECTION AND
THE **FIFTH** FROM EITHER SECTION. USE ILLUSTRATIONS WHERE NECESSARY.
USE SEPARATE ANSWER BOOKS FOR EACH SECTION.

SECTION A: INVERTEBRATES

1. Summarise each of the following characteristics used in animal classification:
   (a) Type of symmetry.
   (b) Number of embryonic germ layers.
   (c) Presence or absence of segmentation.
   (d) Appendages.
   (e) Type of body cavity.

2. Compare and contrast the types of asexual reproduction in protozoans and in sponges.

3. (a) Describe the features that have made arthropods the most successful group among
       invertebrates.
   (b) Explain how circulation and respiration are achieved in arthropods.

4. (a) Describe the water vascular system in members of the phylum Echinodermata.
   (b) Explain the feature of regeneration in sea stars following amputation.

SECTION B: VERTEBRATES

5. Summarise each of the following:

   (a) Cyclostomata.
   (b) Tetrapoda.
   (c) Sarcopterygii.
   (d) Ichthyosauria.
   (e) Ungulates.

6. Compare and contrast the classes Chondrichthyes and Osteichthyes.

7. Describe characteristics of the class Amphibia that are typical of the subphylum
   Gnathostomata.

8. Discuss the diversity of reproductive systems in the class Mammalia.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

BIO 3212: INSECT TAXONOMY, CLASSIFICATION AND IDENTIFICATION
THEORY PAPER

TIME: THREE HOURS

INSTRUCTIONS: ANSWER **FIVE** QUESTIONS; **TWO** QUESTIONS FROM EACH
SECTION AND THE **FIFTH** QUESTION FROM EITHER SECTION.

SECTION A: PRINCIPLES AND METHODS OF TAXONOMY AND INSECT NOMENCLATURE

1. Explain roles of the following people in the development of the science of biological taxonomy:
   (a) Augustin de Candole (18th Century).
   (b) John Ray (17th Century).
   (c) Aristotle (384-322 BC).
   (d) Carl Linnaeus (1707-1778).

2. Explain what the Linnean hierarchy is and how it is presently used in biological classification.

3. Distinguish between Phenetic and Cladistic schools of thought in biological taxonomy and explain why both schools are still maintained today despite the serious differences between them.

4. Discuss the basic tenets of the botanical, bacteriological and zoological codes of nomenclature.

SECTION B: INSECTI CLASSIFICATION AND IDENTIFICATION

5. Discuss the phylogenetic relationships of members of Infraclasses Paleoptera and Neoptera among insects and show how both are related to the Apterygota.

6. Discuss the classification and economic importance of members of Orthopteroid orders of Class Hexapoda.

7. Explain why members of the Endopterygota are considered to be advanced groups among insects.

8. Distinguish the following methods of insect identification and indicate when they are practical:
   (a) Use of dichotomous identification taxonomic keys.

(b) Comparisons with nomenclatural types.
(c) Use of voucher specimens.
(d) Visual insect identification.

END OF EXAMINATION

UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
FINAL EXAMINATIONS 2014/2015 ACADEMIC YEAR
C2615: BASIC PHYSICAL CHEMISTRY

Duration: Three (3) Hour

Instructions:

This question paper is divided in two sections: **A (40)** and **B (60)**.

Answer **allquestions** in section A

Answer **3 questions in** Section B

Answer Section A and B in **separate answer booklets**.

You are reminded to answer questions in a clear and logical manner.

Useful Information and Constants:

R= 8.314 Jmol^{-1} K^{-1}, h= 6.63 x 10^{-34}Js, N = 6.02 x 10^{23} mol^{-1},

Boltzmann constant= 1.381 x 10^{-23}JK^{-1}, 1 mass unit = 1.6605 x 10^{-27} kg.

Molar volume of gas at STP = 22.4 dm^{3}mol^{-1}, STP = 273 K and 1 atm

Avogadro's constant = 6.02 x 102^{3}mol^{-1}

Atomic weight: H 1.00, He 4.00, C 12.00, N 14.00, Na 22.98, O 15.99

Question A1

A sample of helium gas, $He_2(g)$, has a mass of 11.28 g. At STP, the sample has a volume of 63.2 L. What is the molar volume of this gas at 32.2°C and 98.1 kPa?

Question A2

The van der Waals equation is a thermodynamic equation describing gases under a given set of pressure (P), volume (V), and temperature (T) conditions (i.e., it is a thermodynamic equation of state).

(a) What is the significance of this equation?
(b) Identify/explain each of the parameters in the equation.

Question A3

How much work in joules is done when a piston expands from a volume of 13.27 litres to 76.5 litres against a pressure of 1489 atm?

Question A4

The molar heat of vaporization for ethanol is 39.3 kJ/mol and the boiling point is 78.3°C. Calculate the entropy change for the vaporization of 50.0 g of ethanol.

Question A5

At 1000°C, cydobutane (C_4H_8) decomposes in a first·order reaction, with a very high - rate constant of 87 s^{-1} to two molecules of ethylene (C_2H_4).

(a) If the initial C_4H_8 concentration is 2.00 M, what is the concentration after 0.010 s?
(b) What fraction of C_4H_8 has decomposed in this time?

Question A6

What is the half-life of a radioisotope that has a rate constant of 0.225 d^{-1}?

Question A7

The limiting molar conductance, Λ°_m, of NaI, $NaCH_3CH_2$, $MgCH_3CH_2$, are12.69 mS m^2 mol^{-1}, 9.10 mS m^2 mol^{-1}, and 18.78 mS m^2 mol^{-1} respectively, all at 25 °C. Use Kohlraush's law of the independence of migration of ions to calculate the limiting molar conductance of MgI

Question A8

The mobility of the acetate ion.CH_3COO^-, in aqueous solution at 25 °C is 4.24 $\times 10^{-8}$ $m^2 s^{-1} V^{-1}$. Calculate the molar ionic conductance of the ions.

SECTION B: ANSWER THREE QUESTIONS

Question B1

(a) A gaseous compound contains 92.31% carbon and 7.69% hydrogen by mass. 4.35 g of the gas occupies 4.16 L at 22.0°C and 738 torr. Determine the molecular formula of the gas. **[8]**
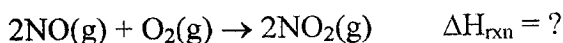
(b) Engineers design automobile air bags that deploy most instantly on impact. To do this, an air bag must provide a large amount of gas in a very short time. Many automobile manufacturers use solid sodium azide, NaN_3, along with suitable catalysts, to provide the gas that is needed to inflate the air bag. The balanced equation for this reaction is
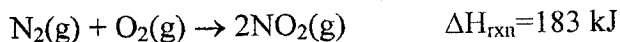
$$2NaN_3(g) \rightarrow 2Na(s) + 3N_2(g)$$
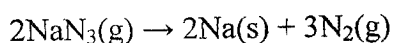
   (i) What volume of nitrogen gas will be produced if 117.0 g of sodium azide are stored in the steering wheel at 20.2°C and 101.2 kPa? **[5]**

   (ii) How many molecules of nitrogen are present in this volume? **[1]**

   (iii) How many atoms are present in this volume? **[1]**

(c) Dry air contains 78.08% nitrogen, 20.095% oxygen, and 0.93% argon. Calculate the partial pressure of each gas in a sample of dry air at 760 torr. Calculate also the total pressure exerted by the three gases combined. **[5]**

Question B2

(a) Three moles of an ideal gas expand isothermally and reversibly from 90 to 300 L at 300 K. Calculate ΔE_m, ΔS_m, w per mole and q per mole. **[8]**

(b) Use the standard reaction enthalpies given below to determine the ΔH_{rxn} for the following reaction: **[3]**

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g) \qquad \Delta H_{rxn} = ?$$

Given

$$N_2(g) + O_2(g) \rightarrow 2NO_2(g) \qquad \Delta H_{rxn} = 183 \text{ kJ}$$
$$\tfrac{1}{2}N_2(g) + O_2(g) \rightarrow NO_2(g) \qquad \Delta H_{rxn} = 33 \text{ kJ}$$
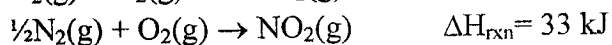
(c) Consider that $\Delta S° = 144.6$ J/K for the sublimation of iodine, $I_2(s) \rightarrow I_2(g)$ $\Delta H° = 62.4$ kJ

   (i) Calculate the standard free energy, $\Delta G°$, for this phase change at 25°C. **[4]**

   (ii) Is the reaction spontaneous at 25°C? **[1]**

   (iii) Calculate the sublimation point (the temperature when sublimation occurs in °C) for iodine. Assume the values for $\Delta H°$ and $\Delta S°$ are valid over the range of temperatures involved. **[4]**

3

Question B3

(a) Derive an expression for integrated rate law for the second order reaction

$$A + B \rightarrow Products$$
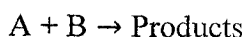
Where [A] = [B] **[6]**

(b) Sketch the straight line graph that is obtained for a second order reaction. **[3]**

(c) Derive an expression for half life from your answer in part (a). **[4]**

(d) Ethyl-2-nitrobenzoate ($NO_2C_6H_4CO_2C_2H_5$) hydrolyzes under basic conditions. A plot of [$NO_2C_6H_4CO_2C_2H_5$] versus t was used to calculate $t\frac{1}{2}$, with the following results:

[$NO_2C_6H_4CO_2C_2H_5$] (M/cm^3)	$t_{\frac{1}{2}}$ (s)
0.050	240
0.040	300
0.030	400

What is the order of the reaction? Explain your reasoning. **[2]**

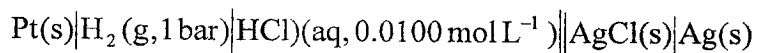(e) The rate equation for the reaction between compounds C and D is

$$rate = k[C][D]^2$$

(i) In an experiment where the initial concentration of C is 0.15 $moldm^{-3}$ and the initial concentration of D is 0.24 $moldm^{-3}$, the initial rate of reaction is 0.65 $moldm^{-3}s^{-1}$ at a given temperature. Calculate a value for the rate constant, k, at this temperature and deduce its units. **[2]**

(ii) The reaction between C and D is repeated in a second experiment at the same temperature, but the concentrations of both C and D are half of those in part (a)(i). Calculate the initial rate of reaction in this second experiment. **[3]**

Question B4

(a) A saturated solution of Ag_2CO_3 had an electrical resistance of 3529.6 Ω when measured in a conductance cell with a cell constant of 38.54 m^{-1} at 25 °C. The specific conductance of water was 0.00760 $\Omega^{-1}m^{-1}$. The limiting molar conductance, Λ_m°, of Ag_2CO_3 is 0.02624 $\Omega^{-1}m^2mol^{-1}$ at a temperature of 25 °C.

(i) Calculate the specific conductance of Ag_2CO_3 corrected for the specific conductance of water. **[5]**
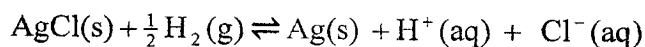
(ii) Determine the solubility of Ag_2CO_3. **[5]**

(b)   Consider a cell, below at a temperature of 25 °C,

$$Pt(s)|H_2(g,1\,bar)|HCl)(aq, 0.0100\,mol\,L^{-1})\|AgCl(s)|Ag(s)$$

The standard half-cell reduction potentials are

$$AgCl(s)+e^- \rightleftharpoons Ag(s) + Cl^-(aq) \quad E° = 0.2224\,V$$

$$H^+(aq)+e^- \rightleftharpoons \frac{1}{2}H_2(g) \qquad E° = 0.0\,V$$
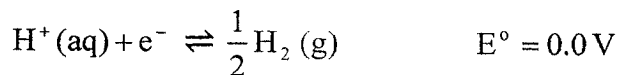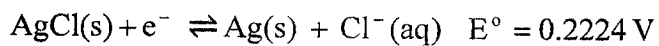
The cell reaction is

$$AgCl(s)+\tfrac{1}{2}H_2(g) \rightleftharpoons Ag(s) + H^+(aq) + Cl^-(aq)$$

(i)   Use the Debye- Hückell limiting law to calculate the mean ionic activity coefficient of HCl.   [3]

(ii)   Apply the Nernst equation determine the emf of the cell.   [7]

END OF EXAMINATION

5

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE1000: INTRODUCTION TO CHEMISTRY

TIME: THREE (3) HOURS

INSTRUCTIONS TO THE CANDIDATES

1. Indicate your **student ID number** and **TG number** on **ALL** your answer booklets.

2. This examination paper consists of two (2) sections: **A** and **B**

3. Section **A** has ten **(10)** short answer questions.
    Questions carry equal marks.(Total marks = **40**).

    ANSWER ALL QUESTIONS IN SECTION A IN THE MAIN ANSWER BOOKLET

4. Section **B** has five **(5)** long answer questions.
    Questions carry equal marks.(Total marks = **60**).

    ANSWER QUESTION B1 and ANY THREE QUESTIONS, EACH IN A SEPARATE ANSWER BOOKLET.

6. **YOU ARE REMINDED OF THE NEED TO ORGANISE AND PRESENT YOUR WORK CLEARLY AND LOGICALLY.**

7. **ENSURE** that you have eight (8) printed pages and Periodic Table.

ADDITIONAL INFORMATION TO THE CANDIDATES:

1. **Useful data is printed on page 8.**
2. **Periodic table is printed on the last page**

Question A1

Calculate the mass of sodium hydroxide needed to make a 5.00 L solution with a molarity of 0.400 M.

Question A2

What is the de Broglie wavelength of a helium atom of atomic mass of 4.003 amu travelling at a velocity of 1000.0 m s^{-1}?
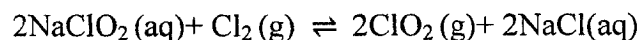
Question A3

In an atom of an element, state the quantum numbers that defines an atomic orbital and their allowed values.

Question A4

A 500. g copper forcepswas accidentally left on a heating mantle until it had a temperature of 35 °C. A student then placed the forceps in 70 g of water at 22 °C to cool it off. Calculate the specific heat capacity of the copper forceps if the final temperature of the water was 27 °C. (Specific heat capacity of water is 4.18 J/g. °C).

Question A5

Calculate the cell potential (E°) for the reaction below and determine whether it will proceed in the direction in which it is written under standard conditions.
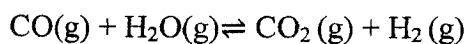
$2NaClO_2$ (aq)+ Cl_2 (g) ⇌ $2ClO_2$ (g)+ $2NaCl$(aq)

Question A6

(a)   What are the units of the rate constant for the following reaction?

$$2NO_2(g) \rightarrow N_2O_4(g) \qquad\qquad Rate = k\,[NO_2]^2$$

(b)   Calculate the rate at which N_2O_4 is formed in the following reaction at a moment in time when NO_2 is being consumed at rate of 0.0592 mol dm^{-3}s^{-1}.

Question A7

Consider the following reaction:

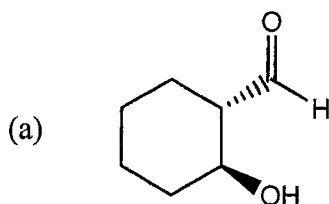$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

If a 10.00L vessel has 2.50 mol CO_2 and H_2O, and 5.00 mol CO_2 and H_2 gas at 588 K, which way will the reaction proceed? (K_c = 31.4 at 588 K)

Question A8

If 152 g of Na_2SO_4 are dissolved in 875 g of H_2O, what will be the freezing point of the resulting solution. Assume 100% ionization, K_f = 1.86 °C/m

Question A9

Provide the IUPAC name for each of the following compounds:

(a)

(b)

Question A10

Give a skeletal (line) formula:

(a) Allyl benzyl ether

(b) 3-Methylheptane-2,5-dione

(c) 2-aminobenzenenitrile (2-aminobenzonitrile).

3

Question B1

In Experiment 3 – The Stoichiometry of Chemical reaction – one of the experimental run involved mixing 2.50 mL of 0.500 M barium chloride, $BaCl_2$, and7.50 mL of 0.500 M sodium sulphate, Na_2SO_4 solution. The height of barium sulphate precipitate formed in the test-tube was measured.

(a)   Write the balanced molecular and net ionic reaction involved in the experiment.

(2marks)

(a)   Identify the limiting reagent.Justify your answer by appropriate calculations.

(7marks)

(b)   Calculate the mass of barium sulphate (molar mass =233.40 g/mol) formed.**(4marks)**

(d)   What was the main source of error in the experiment?   **(2marks)**

Question B2

(a)   (i)   Draw a ground state electronic orbital energy diagram of nitrogen and oxygen atoms using orbital box notation.   **(3marks)**

        (ii)   Explain in two sentences why the first ionisation energy of O (1320 kJ mol^{-1}) is less than that of N (1410 kJ mol^{-1}) despite the fact the highest orbitals in N and O are in the same energy level.   **(2 marks)**

        (iii)   Calculate the ionisation energy of $_1^1H$ in kJ mol^{-1}.   **(4marks)**

(b)   (i)   Explain trend in boiling points of the following: **(2 marks)**

                HCl, – 85 °C; HBr, –67 °C;HI, –15 °C

        (ii)   Use Lewis diagrams to illustrate the formation of HCl from its elements

(c)   Use Hess's Law to determine ΔH for the reaction: $C_3H_4(g) + 2H_2(g) \rightarrow C_3H_8(g)$

(2 marks)

        (1) $H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(l)$ ΔH = – 285.8 kJ
        (2) $C_3H_4(g) + 4O_2(g) \rightarrow 3CO_2(g) + 2H_2O(l)$ ΔH = –1937 kJ
        (3) $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ ΔH = – 2219.1 kJ

**Question B3**

(a) The diagram below shows a cell that can be used to measure the standard electrode potential for the half-reaction Fe^{3+} (aq) + e^- ⇌ Fe^{2+} (aq). In this cell, the electrode on the right-hand side is positive.

Left hand side **Right hand side** **D**
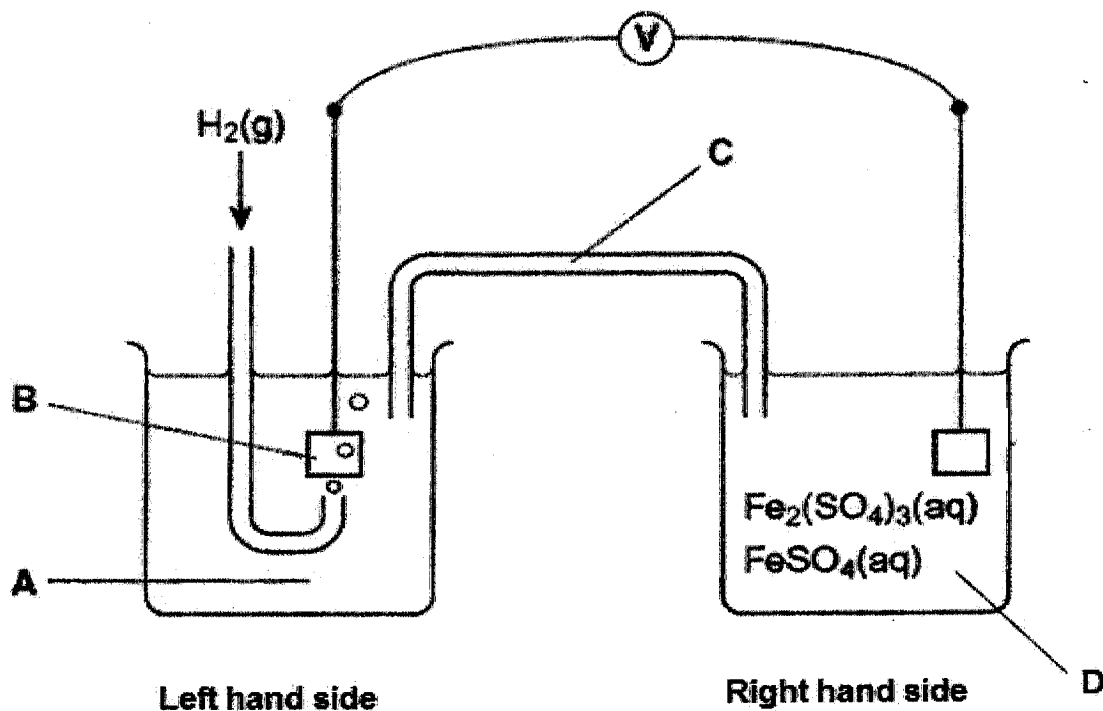
(i)   Identify solution **A** and give its concentration. State one other essential condition for the operation of the standard electrode that forms the left-hand side of the cell.

(2marks)

(ii) Identify the material from which electrodes **B** is made. Give **two** reasons why this material is suitable for its purpose.   **(2marks)**

(iii) Identify a solution that could be used in **C** to complete the circuit. Give **two** reasons why this solution is suitable for its purpose.   **(2marks)**

(iv) Write the conventional representation for this cell.   **(2marks)**

(v)   Write an equation for the overall cell reaction that would occur.   **(2marks)**

(vi) The voltmeter **V** shown in the diagram of the cell was replaced by an ammeter. Explain why the ammeter reading would fall to zero after sometime time.

(1mark)

5

(b) A curious CHE1000 student analysed the 10.00 mL sample of the solution **D** to determine the concentration of Fe^{2+} ions by titrating the acidified solution with a standard potassium permanganate solution.

$$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$$
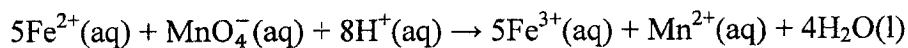
10.0 mL the solution was titrated potassium permanganate solution of concentration 0.0200 molL^{-1}. Volume of potassium permanganate used for complete reaction was 37.5 mL.

Calculate the following:

(i) oxidation state of Mn in potassium permanganate. **(1 mark)**

(ii) number of moles of permanganate ions used. **(2 marks)**

(iii) number of moles of iron(II) ions in 10.0mL of solution. **(1 mark)**

Question B4

(a) For a first order reaction, $A \rightarrow C + D$, at 300.0 K, the concentration of **A** was reduced to one half of its initial value after 5000.0 s. At 310.0 K, the concentration of **A** was halved after 1000.0 s.

(i) Calculate the rate constant for the reaction at 300.0 K and 310.0 K. **(3 marks)**

(ii) Determine the activation energy of the reaction **(5 marks)**

(b) Consider the equilibrium reaction below with a K_{sp} of 4.68×10^{-6} at 25°C

$$Ca(OH)_2(s) + H_2O(l) \rightleftharpoons Ca^{2+}(aq) + OH^-(aq)$$
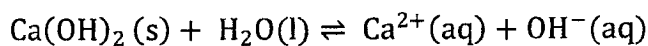
(i) Calculate the solubility of $Ca(OH)_2$ in mol L^{-1}. **(4 marks)**

(ii) Determine the pH of the saturated solution. **(3 marks)**

Question B5

(a) A frequently used food preservative, **P**, is made as shown below:

+ NaOH $\longrightarrow$ **P** + **Q**
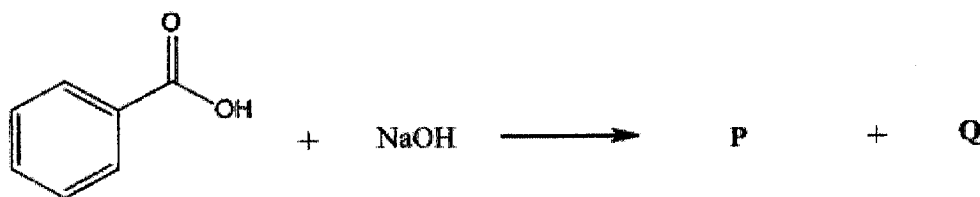
(i)	Name the type of reaction.	**(1 mark)**
(ii)	What is the structure of **P**?	**(1 mark)**
(iii)	Give IUPAC name for **P**.	**(1 mark)**

(b) Several constitutional (structural) isomers can be written for the molecular formula C_5H_9OBr.

(i) Calculate the DBE (IHD) and state all possible interpretations. **(2 marks)**

(ii) One of the isomers decolorizes bromine water. Does this isomer has a ring? Give a reason. **(2 marks)**

(iii) Give a line formula for another isomer that is a <u>straight chain acyl bromide</u> (acid bromide). **(2 marks)**

(c) Consider the drug atenolol, used for treatment of hypertension (high blood pressure), shown below:
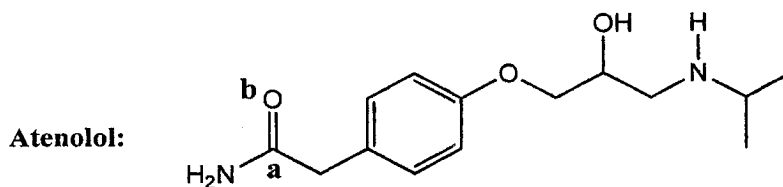
Atenolol:

(i) Identify all functional groups in atenolol. **(2 marks)**

(ii) For the labeled atoms **a** and **b**, state the kind of orbitals that overlap to form each bond. **(2 marks)**

(d) Give the structures for **two** C_8 alkane constitutional (structural) isomers with parent chain name as hexane. **(2 marks)**

---END OF EXAM-------------------------------------

USEFUL DATA

Physical constants

Avogadro constant, N_A	6.022×10^{23} mol^{-1}
Acceleration due to gravity	9.8 m s^{-2}
Faraday's constant, F	96485 C mol^{-1}
Mass of electron, m_e	9.11×10^{-31} kg
Planck's constant, h	6.626×10^{-34} J s
Rydberg constant, R_H	1.097×10^7 m^{-1}
Speed of light, c	3.00×10^8 m s^{-1}

Universal gas constant, R

8.3145 J mol^{-1} K^{-1}
0.083145 L bar mol^{-1} K^{-1}
0.08206 L atm mol^{-1} K^{-1}
62.364 L torr mol^{-1} K^{-1}
62.364 L mmHg mol^{-1} K^{-1}

1 amu = 1.6605×10^{-27} kg

$$E_n = -2.18 \times 10^{-18} \text{ J } \frac{1}{n^2}$$

Pressure conversions

1 atm = 1.01325×10^5 Pa = 1.01325×10^5 N m^{-2} = 760 torr = 760 mmHg
= 1.01325 bar

1 bar = 1.00000×10^5 Pa
= 1.00000×10^5 N m^{-2}

Other conversion factors

V = JC^{-1} 1 eV = 1.602×10^{-19} J

1 J = 1 kg m^2 s^{-2}

$Cl_{2(g)} + 2e^- \rightleftharpoons 2Cl^-_{(aq)}$	$E° = 1.36$ V
$2ClO_{2(g)} + 2e^- \rightleftharpoons 2 ClO_2^{\cdot -}{}_{(aq)}$	$E° = 0.954$ V
$H^+ + e^- \rightleftharpoons \frac{1}{2} H_2$	$E° = 0.00$ V
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	$E° = 0.77$ V

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number
X
Atomic mass
Name of the element X

Group 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01 Hydrogen																	2 **He** 4.00 Helium
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.55 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 Indium	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 Tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
55 **Cs** 132.91 Caesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89 - 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **Unh** 263.12	107 **Uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

57 **La** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** 144.91 Promethium	62 **Sm** 150.36 Samarium	63 **Eu** 151.97 Europium	64 **Gd** 157.25 Gadolinium	65 **Tb** 158.93 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thulium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium
89 **Ac** 227.03 Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** 244.0 Plutonium	95 **Am** 243.06 Americium	96 **Cm** 247.07 Curium	97 **Bk** 247.07 Berkelium	98 **Cf** 251.08 Californium	99 **Es** 252.08 Einsteinium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE 2112: INTRODUCTORY BIOCHEMISTRY

TIME: THREE HOURS

INSTRUCTIONS:

1. Answer any **FIVE (5)** questions.
2. Ensure that there are **FOUR (4)** printed pages in this examination paper.
3. Each question carries **TWENTY (20)** marks.

NOTE: Useful information is on page 4

QUESTION 1

a) What is the **significance** of hydrogen bonding on the properties of water?   **[2 marks]**

b) The K_a of formic acid (HCOOH) is 1.77×10^{-4} at 25 °C. **What** is the pH of a 0.01 M solution of formic acid in water?   **[6 marks]**

c) You were introduced to the acetic acid- acetate buffer as part of the laboratory experiments. Suppose a buffer solution was 0.2 M in acetic acid and acetate. The buffer species are equimolar.
   Calculate the change in pH upon adding 1.0 ml of 0.1 M HCl to 10 ml of this solution. **What** assumptions do you make to arrive at a mathematically correct estimate?
   (K_a of acetic acid is 1.75×10^{-5})   **[12 marks]**

QUESTION 2

a) **Draw** the structure of the polypeptide Gly-Trp-Tyr-Gln-Arg at pH 7 and **calculate** the net charges at the following pH values:
   i. pH 2.0
   ii. pH 7.0
   iii. pH 11.0

                                                                    [12 marks]

b) **Draw** the possible structure(s) of the above polypeptide that you would observe at pH 2.2. **[3 marks]**

c) If the polypeptide chain was broken and the amino acids were separated, **sketch** and **label** the titration curve for arginine from pH 1 to pH 13 using NaOH. **[5 marks]**

QUESTION 3

a) Ribose sugar can undergo cyclization to form a sugar that is associated with DNA and RNA, **what** other components are required to form a nucleoside? **[3 marks]**

b) **Draw** a diagram illustrating the sugar phosphate backbone and the linkage between Guanine and Cytosine. **[6 marks]**

c) An isolated strand (+) of DNA has a base composition of 20% A, This is replicated by DNA polymerase into a complimentary strand (-).
   i. **What** is the expected composition of bases in the (-) strand produced by the DNA polymerase? **[4 Marks]**
   ii. If B DNA is produced consisting of 10 000 base pairs, **what** is the name and length of the secondary structure that would form? **[4 marks]**
   iii. **What** would the volume of this structure be? **[3 marks]**

QUESTION 4

a) Define a lipid. **[2 marks]**

b) 1 mole of an optically active phospholipid was subjected to hydrolysis to yield 1 mole of glycerol, 1 mole of phosphate and 2 moles of a fatty acid ($16:2^{\Delta 9,12}$).
   i. **Draw** the possible structure(s) of the original phospholipid.
   ii. **What** is the IUPAC name for the fatty acid?

   [12 marks]

c) One use of a diacylglyceride would be in the making of soap, **what** is this process referred to as? **Illustrate** this process using the structure you have drawn in part b (i). **[6 marks]**

QUESTION 5

(a) **State** whether each of the statements below is TRUE or FALSE, if FALSE explain why in ONE sentence only.

    i.   The total energy of a system and its surroundings is constant. **[1 mark]**

    ii.   The change in energy depends only on the initial and final states. **[1 mark]**

    iii.   A process can occur spontaneously only if the sum of entropies of the system and its surroundings decreases. **[1 mark]**

    iv.   At equilibrium, standard free energy change is positive if the concentration of products is more than concentration of reactants. **[1 mark]**

    v.   The K'_{eq} of a reaction at 298 K is equal to 1 if the standard free energy change is equal to 0. **[2 marks]**

(b) Consider the reaction below with $\Delta G^{\circ\prime} = -8360$ J.mol^{-1} and at temperature 298 K:

$$\text{Isocitrate} + NAD^+ + 2e^- + 2H^+ \rightarrow \alpha\text{-ketoglutarate} + CO_2 + NADH$$

    i.   **Identify** the reducing agent in this reaction. **[1 mark]**
    ii.   **Calculate** the $\Delta E^{\circ\prime}$ for the reaction. **[2 marks]**
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    [8 marks]

QUESTION 6

a) **Explain** the following terms and expressions:
    i.   Prosthetic group
    ii.   Transition state
    iii.   Uncompetitive inhibition

    [6 marks]

b) **Show** by means of an appropriately labelled graph what most likely happens to the rate of reaction of a human enzyme when the temperature is increased gradually from 15 °C to 90 °C? Briefly **explain** your answer.

    [4 marks]

c) Copy and complete the following table using the Michaelis-Menten equation to **calculate** the missing values of substrate concentrations A, B, C and D if $V_{max} = 5$ μmol/min. **[10 marks]**

[S] (μM)	V₀ (μmol/min)
10	1.2
A	1.7
B	2.1
C	2.2
D	2.5

END OF EXAMINATION

USEFUL INFORMATION

Gas constant, R	$8.314 \ J.mol^{-1}.K^{-1}$
Faraday's constant, F	$96\ 485 \ J.V^{-1}.mol^{-1}$
B-DNA	Rise per base pair, 3.4 Å
	Pitch, 34 Å
	Diameter, 20 Å
A-DNA	Diameter, 25 Å
Z-DNA	Diameter, 18 Å

Amino acid pK_a values

Name of amino acid	pK_{a1}	pK_{a2}	pK_{a3}
Glycine	2.2	9.4	-
Tryptophan	2.2	9.4	-
Tyrosine	2.2	9.4	10.46
Glutamine	2.2	9.4	-
Arginine	2.2	9.4	12.48

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2014 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE 2522: FUNCTIONAL GROUP AND ARENE CHEMISTRY

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS:

1. This paper contains two sections, **section A** and **section B**, and has **8** printed pages. Ensure you have all printed pages.

2. Section A has three (3) questions. <u>**Answer only two questions from section A.**</u>

3. Section B A has three (3) questions. <u>**Answer only two questions from section B.**</u>

4. <u>Answer section A questions in one booklet and section B questions in a separate booklet.</u> <u>Do not answer questions from section A and section B in the same booklet.</u>

5. Indicate section A/ section B on your answer booklets clearly.

6. Write your TG number (example: TG 5) on the cover page of each answer booklet.

7. Tie both booklets together and submit.

QUESTION A-1

(a) Predict the organic products of the following reactions. **NO** mechanisms are required.

(15 marks)

(i)

(ii)

ịịl
(iⱴ)

iⱴ
(ɤ)
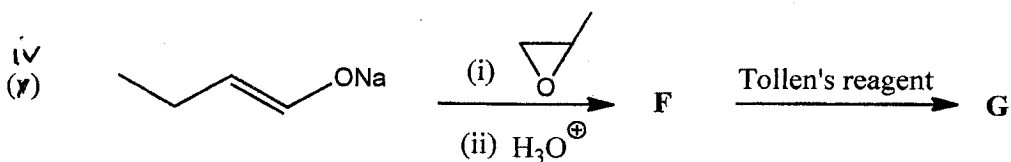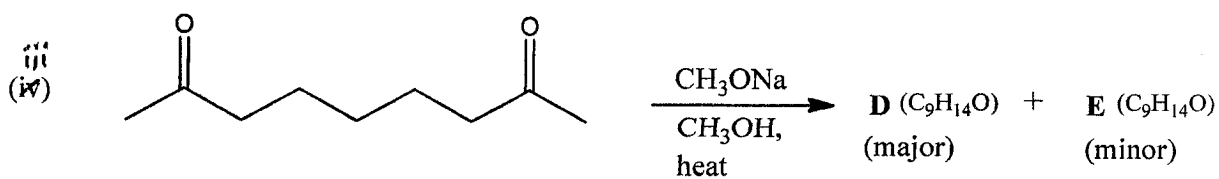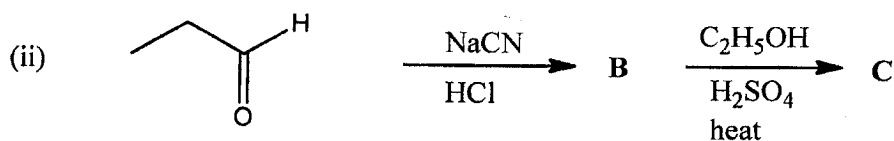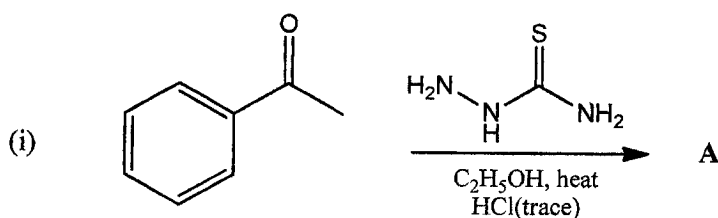
(b) (i) Provide the reagents for iodoform reaction. **(1 mark)**

(ii) Which of the following compounds would give a positive iodoform test?
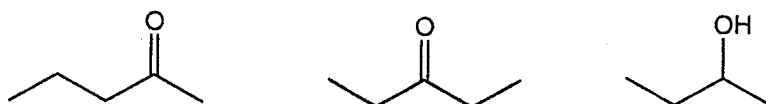
(2 amrks)

(c) An enamine synthesis of 1,3-diketones is illustrated below:

H   (i) ... (ii) H$_2$O, heat   **I**
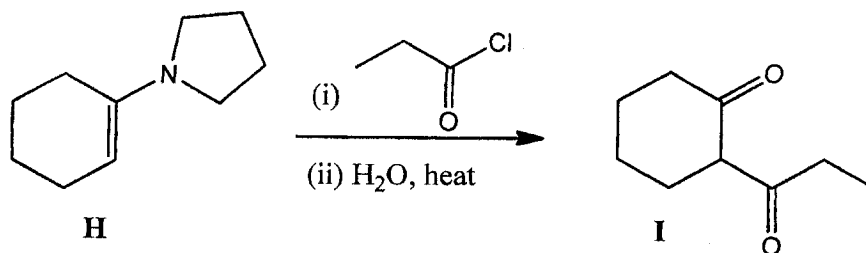
(i)   Suggest mechanisms of both reactions in this synthesis, showing the intermediate clearly.   **(8 marks)**

(ii)   How would you prepare enamine **H** required for the above synthesis? **Do not write reaction mechanism.**   **(4 marks)**

QUESTION A-2

(a) Dieckmann condensation is used for synthesis of a variety of cyclopentanone and cyclohexanone derivatives. An example is shown below:

(i) EtONa
(ii) H$_3$O$^{\oplus}$

J
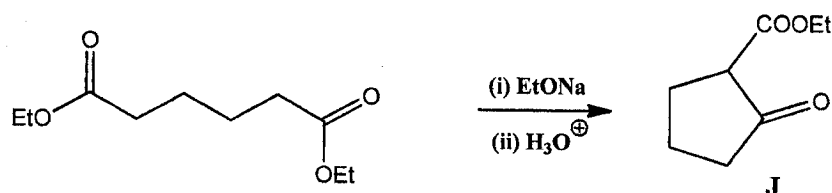
(i)   Provide a detailed mechanism for the reaction, including the resonance stabilisation of the anion intermediates.   **(10 marks)**

(ii)   What starting material you would use to prepare **K** by Dieckmann condensation?

K:

(2 marks)

3
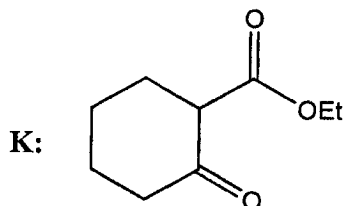
(b) Given that ketones are reduced faster than esters, propose a synthesis of 4-hydroxybutanone, $CH_3COCH_2CH_2OH$, from acetoacetic ester, $CH_3COCH_2COOC_2H_5$, in three steps. Show all steps clearly, including the intermediates. **Do not** write mechanisms.

(**8 marks**)

(c) Assuming that thionyl chloride and ammonia are available, suggest a method for conversion of ethanoic acid into ethanamide (CH_3CONH_2). (**3 marks**)

(d) Predict the product and give mechanisms of the following reaction: (**7 marks**)

$$+ \quad CH_3NO_2 \quad \xrightarrow[CH_3OH]{CH_3ONa} \quad L, C_8H_7NO_2$$
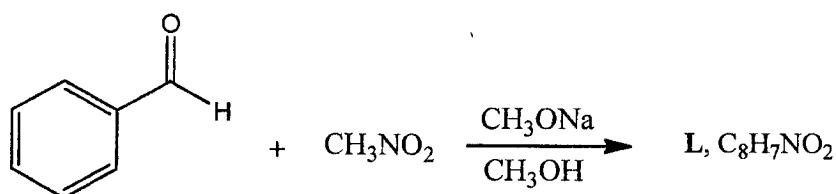
QUESTION A-3

(a) Carboxylic acid group is often protected as tert.-butyl ester in organic synthesis. Unlike methyl and ethyl esters, which are easily hydrolysed by aqueous bases, tert.-butyl esters, $RCOOC(CH_3)_3$, are resistant to alkaline hydrolysis.

Ester   Carboxylate   Alcohol
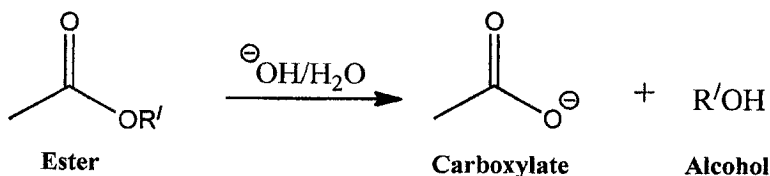
(i) Write the mechanism for alkaline hydrolysis of esters, $RCOOR'$, indicating the rate determining step. (**4 marks**)

(ii) Based on the hydrolysis mechanism you wrote, briefly explain why tert.-butyl esters are resistant to alkaline hydrolysis. (**2 marks**)

4

(b) Predict the products and give mechanisms of the following reactions:

(i)

$$\xrightarrow{H_2SO_4}$$ **P**, $C_6H_{10}O_2$ (a lactone)

(5 marks)

(ii)

 +

$$\xrightarrow[\text{Michael addition}]{KOH/H_2O}$$ **N**, $C_8H_{12}O_3$
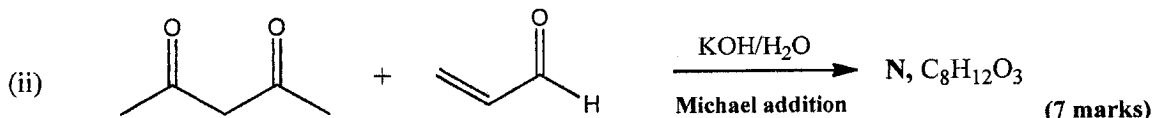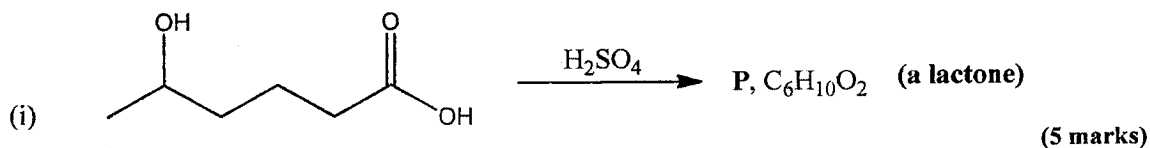
(7 marks)

(c) Propose synthesis of butanoic acid from 1-propanol. Show all steps clearly, including the intermediates. **Do not** write reaction mechanisms. **(5 marks)**
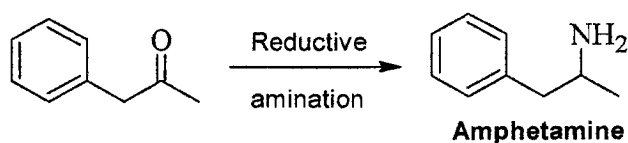
(d) Provide the starting materials/reagents for the following synthesis: **(7 marks)**

(i)

 $$\xrightarrow[\text{reagents?}]{P}$$

(ii) **Q** + **R** $$\xrightarrow[\text{reagent?}]{\cancel{X} \, S}$$
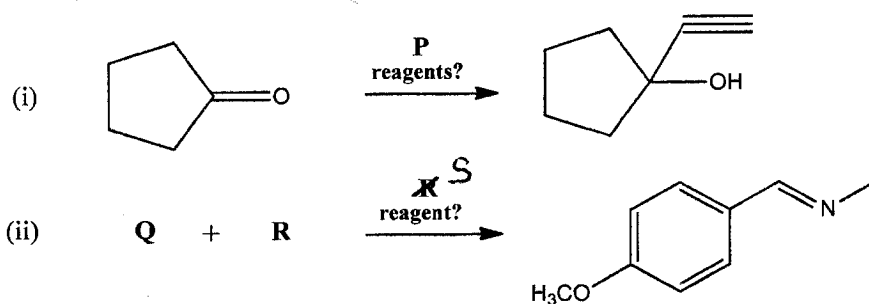
SECTION B: ANSWER ONLY TWO QUESTIONS ONLY

QUESTION B-1

(a) The reaction for the synthesis of a central nervous system stimulant called amphetamine is shown below. **(10 marks)**

 $$\xrightarrow[\text{amination}]{\text{Reductive}}$$
Amphetamine

(i)   Provide all the reagents required.

(ii) Write the reaction mechanism for the synthesis.

(b) Define the following terms: **(6 marks)**

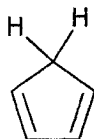   (i)   Aromaticity

    (ii)   Hückel's (4n+2) rule

(c) There are three (3) resonance structures for naphthalene, one of which is shown below. Draw the other two. **(2 marks)**
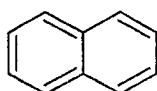
Naphthalene

(d) 1, 3-Cyclopentadiene shown below is a non-aromatic compound. Show how it can be converted into an aromatic compound. Reagents and reaction conditions must be shown.
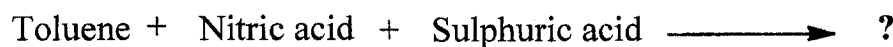

1,3-Cyclopentadiene

(4 marks)

(e) Show the product and write mechanism of the following reaction. **(4 marks)**

Toluene + Nitric acid + Sulphuric acid $\longrightarrow$?

(f) Although N-ethyl-N-methylpropanamine is a chiral molecule it cannot be resolved into its enantiomers. Explain briefly. **(4 marks)**

QUESTION B-2

(a) Propose a route for synthesis for 4-chloro-2-ethylaniline, structure is shown below, from benzene and readily available laboratory reagents. **(10 marks)**


4-Chloro-2-ethylaniline

6
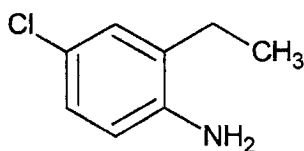
(b) 1-Propanamine boils at 48^0C while its isomer 2-propanamine boils at 32^0C and yet both compounds have the same molecular mass of 59 and both are primary amines. Provide a reason to explain this experimental observation. **(1 mark)**

(c) Assuming that you were provided with three (3) amines: ethylamine, diethylamine and triethylamine. Give the name of the laboratory test you would carry out to distinguish the three amines from each other. Write all the reactions involved in the test and clearly show evidence for distinguishing the three amines. Indicate the starting materials, the reagents and the intermediates. **(10 marks)**

(d) Arrange the following amines in order of increasing basicity. **(2 marks)**

$$Et_2NH; \quad NH_3; \quad EtNH_2; \quad Et_3N$$

(e) Friedel-Crafts alkylation of bromobenzene takes place at the ortho- and para- positions even though bromine is deactivating. Explain this fact with the help of mesomeric effect concept. **(7 marks)**

QUESTION B-3

(a) Write the mechanism of the following reaction which proceeds by electrophilic aromatic substitution mechanism. **(4½ marks)**

$$\xrightarrow[\Delta]{H_2SO_4 \,/\, H_2O}$$
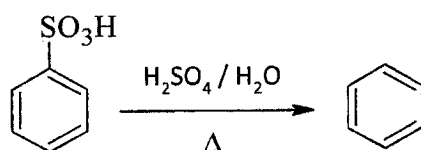
(b) Predict the major organic product of the following reaction and write its mechanism.

$$Me_2NH \; + \; CH_2O \; + \; PhCOCH_3 \;\; \xrightarrow{\;\; H^+ \;\;} \;\; ? \; (A\ base)$$
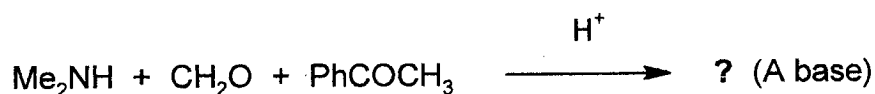
(10 marks)

(c) (i) Propose a synthesis of ethylamine by the Gabriel method. Clearly show the starting material(s) and all reagents required. **The mechanism is not needed.**

(5½ marks)

(ii) A modification to Gabriel procedure for amine synthesis is the reaction of N-alkyl phthalimide with hydrazine as shown below. Suggest a mechanism for this reaction and provide the structural formula and the common name of the amine product. (7 marks)
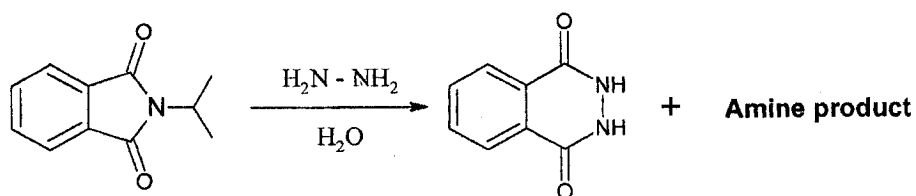
(d) Protonation of acetamide occurs on oxygen rather than on nitrogen. Suggest a reason for this behaviour. (3 marks)
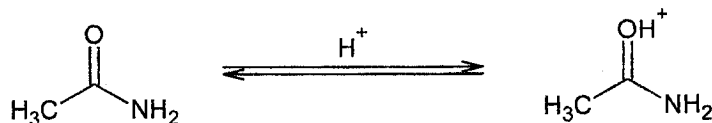
END OF EXAMINATION

8

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY

2014 ACADEMIC YEAR
END-OF-YEAR EXAMINATIONS

CHE3422 – ORGANOMETALLICS AND INORGANIC REACTION MECHANISMS

INSTRUCTIONS:

1. TIME ALLOWED: **THREE (3)** HOURS ONLY

2. ENSURE YOU HAVE **SIX (6)** PRINTED PAGES

3. THIS EXAM PAPER CONSISTS OF **TWO (2)** SECTIONS

4. EACH SECTION HAS **THREE (3)** QUESTIONS

5. ATTEMPT A **TOTAL OF FOUR (4)** QUESTIONS; **TWO (2)** FROM EACH SECTION

6. EACH QUESTION CARRIES **15 MARKS**

7. ANSWER EACH QUESTION IN A **SEPARATE** ANSWER BOOKLET

8. PLEASE PRESENT YOUR WORK IN A **TIDY AND ORDERLY MANNER**

9. PERIODIC TABLE IS ON PAGE SEVEN (7)

Section A

Question One

(a)   A number of lanthanide minerals (*e.g.*, Monozite) are usually deficient in Europium, which is found among Calcium minerals. Comment.

(b)   The <u>observed value</u> of magnetic moment of Pr^{3+} ion is 3.6 BM. What should be the number of unpaired electrons? Account for any anomaly.

(c)   Pick the orange red ion from the following: La^{3+} , Lu^{4+}

Question Two

(a)   Many of the oxides of actinides e.g., U_3O_8, AmO_2 are non stoichiometric but this is true of few lanthanide oxides. Why?

(b)   How would you attempt the following conversion?
(i) UO_3 to UO_2 (ii) UH_3 to UO_2

(c)   What geometrical shape does $UO_2(H_2O)_6^{2+}$ adopt. Draw the structure. Comment on the U-O bond length.

Question Three

(a)   Explain the major reactions involved in a breeder reactor. How is it more useful than an ordinary nuclear reactor?

(b)   C-14 is a radioactive form of a very common element C-12. Where is C-14 relative to C-12 on the band of stability.

(c)   Sr-90 has been found to occur in radioactive 'fall out'. Why is there so much concern about this isotope being found in cow's milk.
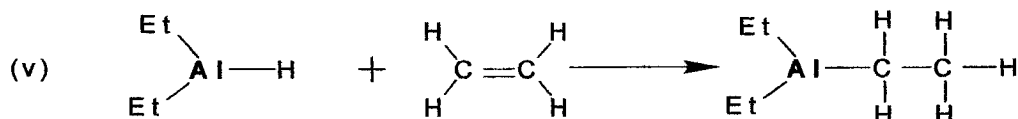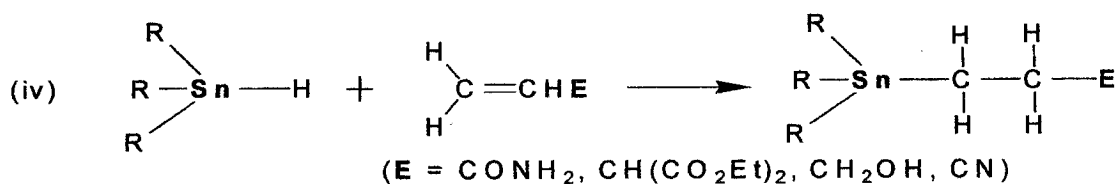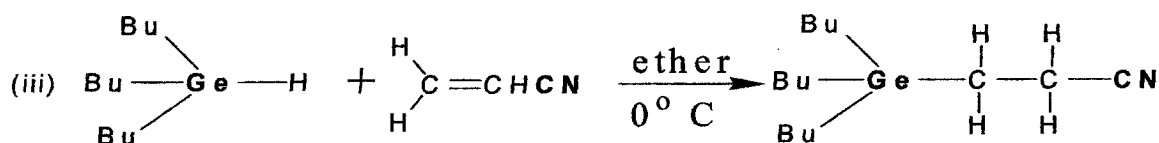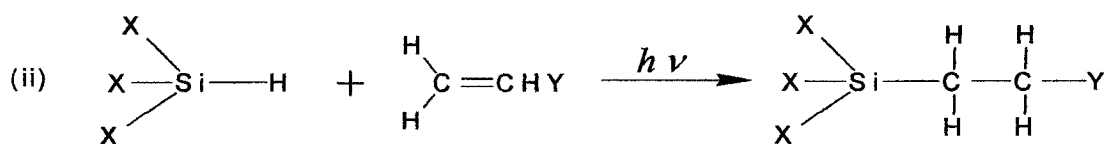
Section B

Question One
(a) Specify the following hydrometallation reactions:

(i) $\text{H}_2\text{B}{-}\text{H} \; + \; \text{C}{=}\text{C} \; \longrightarrow \; \text{H}_2\text{B}{-}\text{C}{-}\text{C}{-}\text{H}$

(ii) $\text{X}_3\text{Si}{-}\text{H} \; + \; \text{H}_2\text{C}{=}\text{CHY} \; \xrightarrow{h\nu} \; \text{X}_3\text{Si}{-}\text{CH}_2{-}\text{CH}_2{-}\text{Y}$

(iii) $\text{Bu}_3\text{Ge}{-}\text{H} \; + \; \text{H}_2\text{C}{=}\text{CHCN} \; \xrightarrow[0°C]{\text{ether}} \; \text{Bu}_3\text{Ge}{-}\text{CH}_2{-}\text{CH}_2{-}\text{CN}$

(iv) $\text{R}_3\text{Sn}{-}\text{H} \; + \; \text{H}_2\text{C}{=}\text{CHE} \; \longrightarrow \; \text{R}_3\text{Sn}{-}\text{CH}_2{-}\text{CH}_2{-}\text{E}$

$(\text{E} = \text{CONH}_2,\ \text{CH(CO}_2\text{Et)}_2,\ \text{CH}_2\text{OH},\ \text{CN})$

(v) $\text{Et}_2\text{Al}{-}\text{H} \; + \; \text{H}_2\text{C}{=}\text{CH}_2 \; \longrightarrow \; \text{Et}_2\text{Al}{-}\text{CH}_2{-}\text{CH}_2{-}\text{H}$
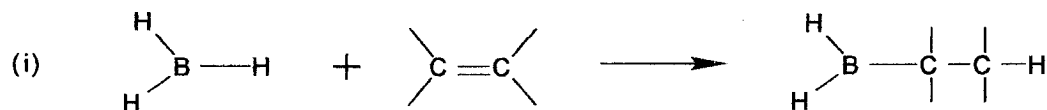
(b) Identify the transition metal in the following 18-electron species:

(i) $[\text{M(CO)}_3(\text{PPh}_3)]^-$ **M** = second-row transition metal

(ii) $(\eta^4\text{-C}_8\text{H}_8)\text{M(CO)}_3$ **M** = second-row transition metal

(iii) $(\eta^5\text{-C}_5\text{H}_5)(cis\text{-}\eta^4\text{-C}_4\text{H}_6)\text{M(PMe}_3)_2\text{H}$ **M** = second-row transition metal

(iv) $(\eta^5\text{-C}_5\text{H}_5)\text{M(C}_2\text{H}_4)$ **M** = first-row transition metal

(v) $[(\eta^5\text{-C}_5\text{H}_5)\text{M(CO)}_3]_2$ (assuming single **M–M** bond) **M** = second-row TM

3

(c) Ferrocene resembles free benzene in that it reacts with many electrophilic reagents, but it does so at an even faster rate than benzene. Complete the reaction scheme below for ferrocene by providing the ferrocene derivatives **A – I**.
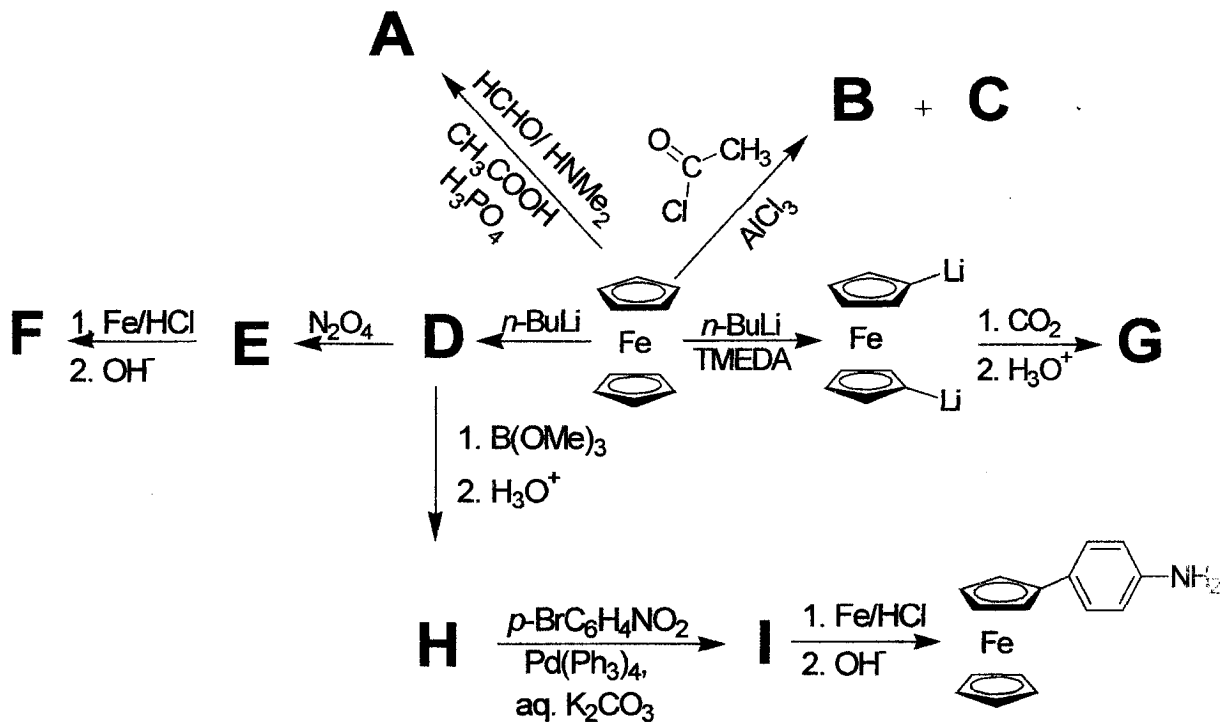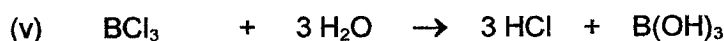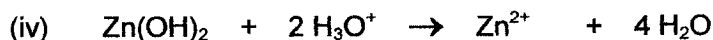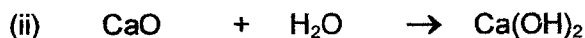

(d) For each of the following pairs of η^n-C_nH_n π-donor rings, choose a first-row transition metal that would form a neutral mixed sandwich compound with.

4
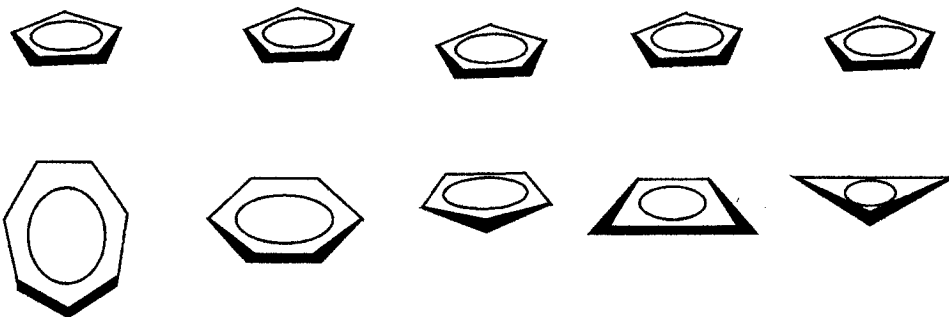
Question Two

(a) Each of the following reactions takes place in aqueous solution. Write an equation that is analogous to each when the solvent is liquid ammonia.

(i) $KOH \ + \ HCl \ \rightarrow \ KCl \ + \ H_2O$

(ii) $CaO \ + \ H_2O \ \rightarrow \ Ca(OH)_2$

(iii) $Mg_3N_2 \ + \ 6\,H_2O \ \rightarrow \ 2\,NH_3 \ + \ 3\,Mg(OH)_2$

(iv) $Zn(OH)_2 \ + \ 2\,H_3O^+ \ \rightarrow \ Zn^{2+} \ + \ 4\,H_2O$

(v) $BCl_3 \ + \ 3\,H_2O \ \rightarrow \ 3\,HCl \ + \ B(OH)_3$

(b) (i) Both BrF_3 and IF_5 are bases in liquid HF. Write equations to show this behaviour.

(ii) Using equations, show how $SbCl_5$ is an acid in liquid $OPCl_3$ in liquid HF, and in liquid BrF_3.

(iii) Write an equation to show why aluminium fluoride is an acid in liquid HF.

(iv) Using equations show how $TiCl_4$ can produce $TiCl_6^{2-}$ in $OPCl_3$ solution.

(v) Write the equation to represent the assumed slight autoionization process of acetic anhydride, $(CH_3CO)_2O$.

(c) Write equations to show the autoionization of the following non-aqueous solvents, clearly indicating the acidic and basic species characteristic of the solvent:
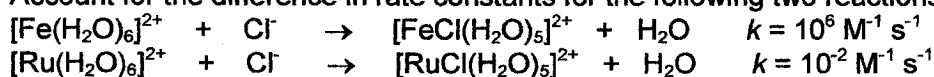
(i) N_2O_4

(ii) HF

(iii) SO_2

(iv) NH_3

(v) IF_5

Question Three

(a)   (i)   The following are approximate rates of exchange of solvent water with bound water for some aqua complexes:

Metal	Na^+	Sr^{2+}	Mg^{2+}	Ni^{2+}	Be^{2+}	Ga^{3+}	Al^{3+}	Ru^{2+}	Cr^{3+}
k (s^{-1})	$\sim 10^9$	$\sim 10^9$	$\sim 10^6$	$\sim 10^5$	$\sim 10^3$	$\sim 10^3$	~ 10	$\sim 10^{-2}$	$\sim 10^{-6}$

Explain how these data are compatible with a dissociative **d** mechanism for water exchange.

(ii)   Account for the difference in rate constants for the following two reactions:

$[Fe(H_2O)_6]^{2+}$ + Cl^- $\rightarrow$ $[FeCl(H_2O)_5]^{2+}$ + H_2O $k = 10^6 \, M^{-1} \, s^{-1}$

$[Ru(H_2O)_6]^{2+}$ + Cl^- $\rightarrow$ $[RuCl(H_2O)_5]^{2+}$ + H_2O $k = 10^{-2} \, M^{-1} \, s^{-1}$

(b)   What is the significance of the following facts taken together for the mechanism of substitution at Co^{3+} in aqueous solution?

(i)   The rates of aquation are always given by the expression rate = $k_{aq}[CoX(NH_3)_5^{2+}]$.

(ii)   No direct replacement of X^- by Y^- is ever observed. Instead, water enters first and is subsequently replaced by Y^-.

(c)   (i)   What is the *trans*-effect as applied to square-planar complexes?

(ii)   Why does the reaction of two moles of PR_3 with K_2PtCl_4 produce a different isomer from that arising from the reaction with two moles of NR_3?

END OF EXAMINATION

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number	**X**
Atomic mass	
Name of the element X	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.01 Hydrogen																	2 **He** 4.00 Helium
3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.55 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 72.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 Indium	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 Tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
55 **Cs** 132.91 Caesium	56 **Ba** 137.33 Barium	57-71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89-103	104 **Unq** 261.11	105 **Unp** 262.11	106 **Unh** 263.12	107 **Uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

57 **La** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** 144.91 Promethium	62 **Sm** 150.36 Samarium	63 **Eu** 151.97 Europium	64 **Gd** 157.25 Gadolinium	65 **Tb** 158.93 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thulium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium
89 **Ac** 227.03 Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** 244.0 Plutonium	95 **Am** 243.06 Americium	96 **Cm** 247.07 Curium	97 **Bk** 247.07 Berkelium	98 **Cf** 251.08 Californium	99 **Es** 252.08 Einsteinium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

7

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
2014 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE 3522
POLYFUNCTIONAL COMPOUNDS, MOLECULAR REARRANGEMENTS AND ORGANIC SYNTHESIS

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS:

1. This paper contains five questions and has 9 printed pages. Ensure you have all printed pages.

2. Answer any four questions.

3. Each question carries 30 marks

4. Answer questions in separate booklets as follows:

   (a) Questions 1 and 2 in one booklet;

   (b) Questions 3 and 4 in one booklet; and

   (c) Question 5 in one booklet

5. Submit all three booklets tied as one.

QUESTION ONE

(a) Provide the missing reagents/intermediates in the following synthesis of serine:

(7 marks)
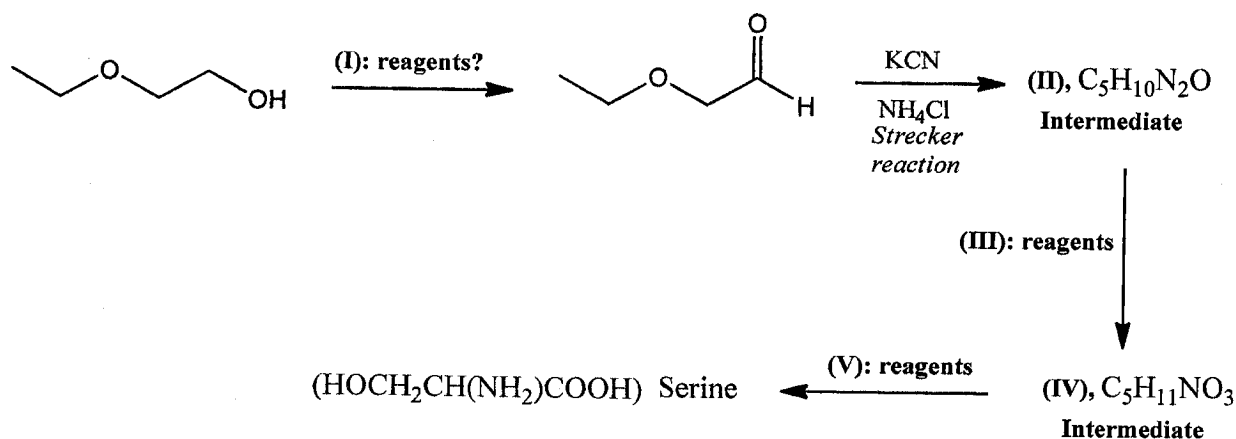
(b) Suggest how the following transformation can be achieved in 3 to 4 steps. Show all steps clearly, including the intermediate(s) for each strep. <u>Do not write reaction mechanisms</u>.

(6 marks)

D-glucofuranose
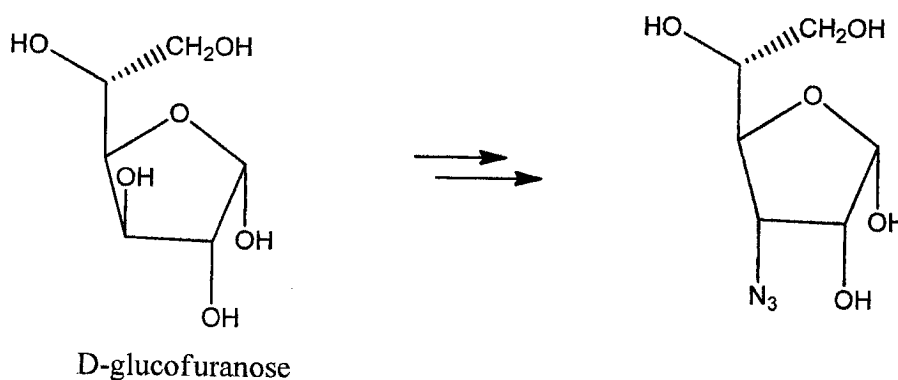
(c) When subjected to Ruff degradation, a D-aldopentose, **A,** gave a D-aldotetrose **B.** Upon sodium borohydride reduction, **A** gave an optically *inactive* alditol **C** while **B** gave an optically *active* alditol **D.**

(i) Propose structures for **A-D**. **(5 marks)**

(ii) Write the reactions involved in the formation of **B** from **A**. **(3 marks)**

(d) Identify the reagents **E** - **I** necessary to achieve each of the following transformations:

(9 marks)
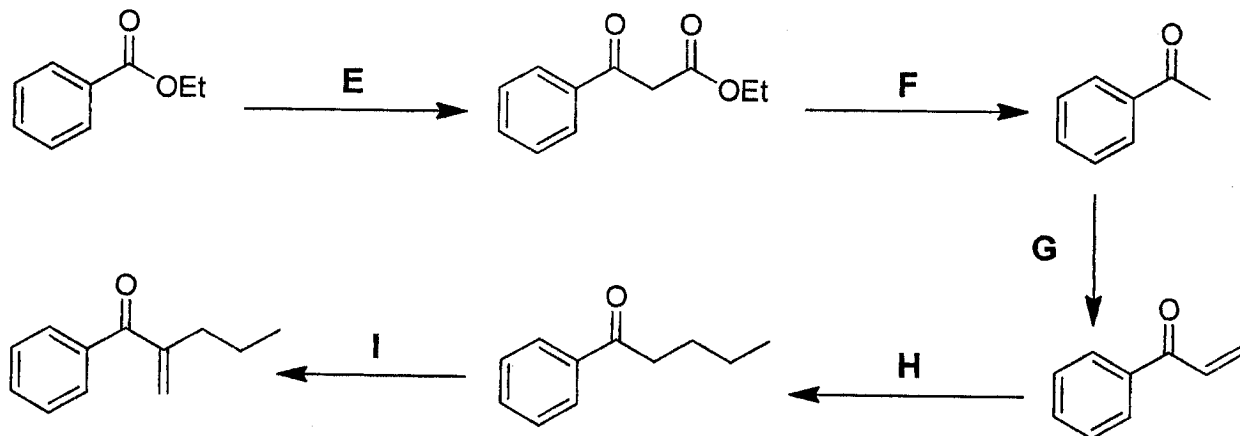
QUESTION TWO

(a) Aspartame, an artificial non-nutritive sweetener, used in manufacture of a wide range of *"sugar free"* food and drinks, is shown below:
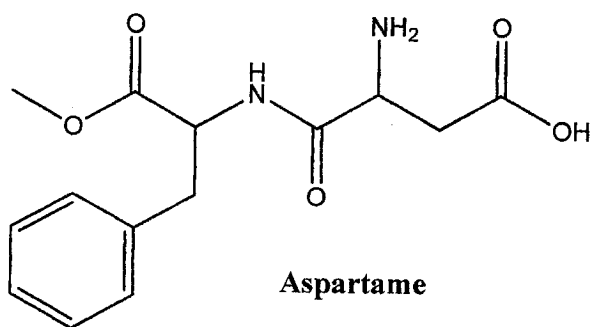
Aspartame

(i)   To which category of organic compounds does aspartame belong?   **(1 mark)**

(ii)   Using "3-letter code" for amino acids, write a short-hand notation for aspartame.

(1 mark)

(iii)   Draw the principal form of aspartame at physiological pH, 7.6.   **(2 marks)**

(iv)   Propose a synthesis of aspartame from aspartic acid, $HOOCCH(NH_2)CH_2COOH$, and phenylalanine, $C_6H_5CH_2CH(NH_2)COOH$. Write all steps clearly, including reagents, solvents (if any), conditions and the intermediate for each step. <u>Reaction mechanisms are **NOT** required.</u>

(10 marks)

3

(b) Consider the structure for gulose shown below:
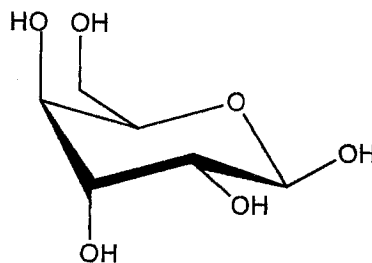
Gulose

(i)   Provide IUPAC name for gulose.   **(2 marks)**

(ii) Give the reagents for osazone formation and the structure for gulosazone.

(3 marks)

(iii) A sugar, **J**, gives the same osazone as gulose. What is the structure of **J**?

(2 marks)

(c) Identify the reagents that will achieve the following transformation: **(4 marks)**
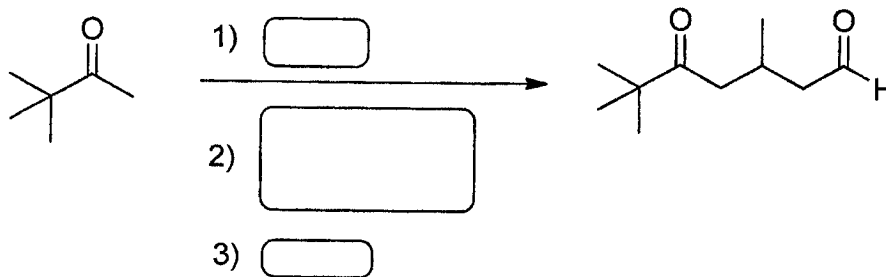
(d) Suggest plausible reaction mechanisms to account for product of the following reaction:

(5 marks)

4
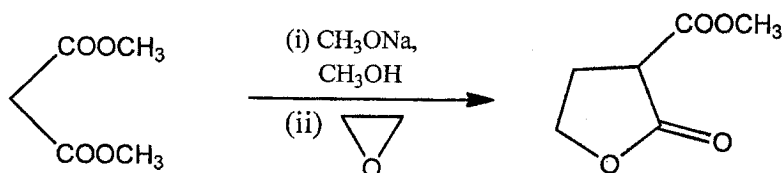
QUESTION THREE

(a) Identify the products of the following reactions: **(4 marks)**

(i)

$$\xrightarrow[\text{heat}]{\text{HCl, H}_2\text{O}} \quad \textbf{K} \ (C_5H_8O_2)$$

(ii) $HOCH_2(CH_2)_2COOH \xrightarrow{H_2SO_4} \textbf{L} \ (C_4H_6O_2)$
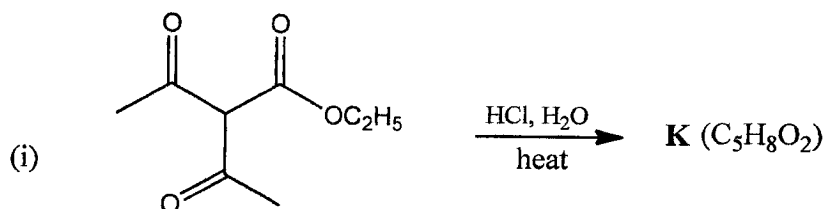
(b) Assuming you have been provided with a molecule, **W-A-B**, where **W** is a migrating group, **A** and **B** are parts of the molecular carbon skeleton called the origin and terminus respectively. On the basis of the molecule **W-A-B**, explain the meaning of the following terms.

(i)   Anionotropic rearrangement **(2 marks)**
(ii) Cationotropic rearrangement **(2 marks)**

(iii) The following reaction proceeds by the Steven's rearrangement.

$$\xrightarrow[\text{Steven's rearrangement}]{^-\text{OH}}$$
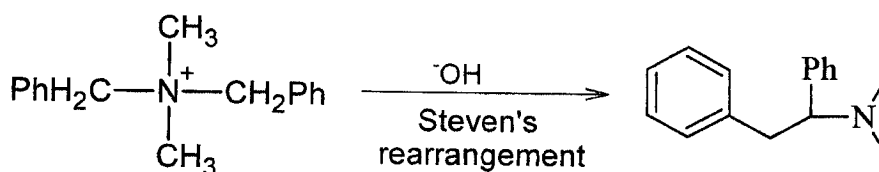
Write the mechanism for this reaction. State clearly whether the reaction is anionotropic or cationotropic. **(6 marks)**

5

(c) By showing the retrosynthesis first, show how you could make each of the following target molecules from the given starting materials.
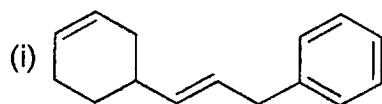
(i) from benzene, buta-1,3-diene, prop-2-en-1-ol and any organic starting material containing no more than two carbons.

(10 marks)
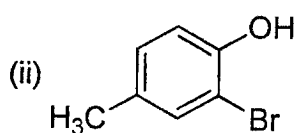
(ii) from toluene

(6 marks)

QUESTION FOUR

(a) Show the products of the following reactions: **(10 marks)**

(i)

(ii)

(iii)

6
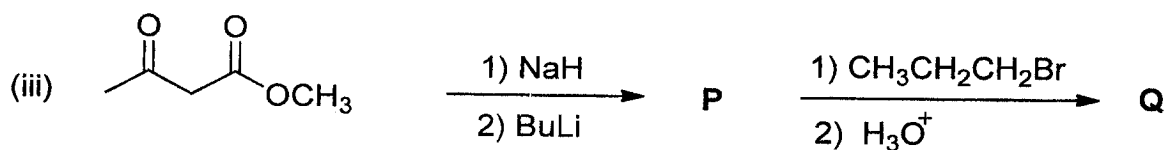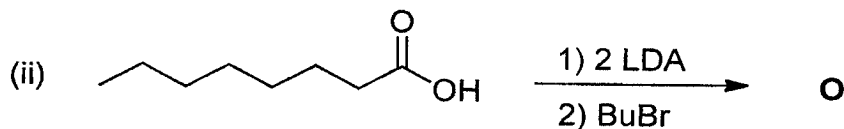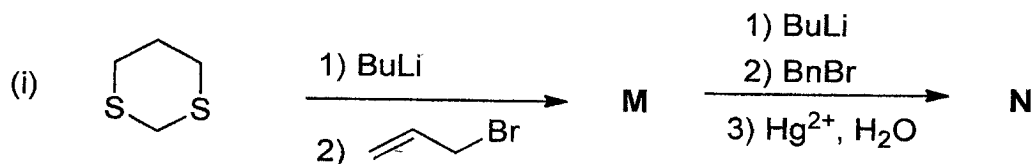
(b) Write the mechanism of the following reactions. In each case, show all the steps involved.
   (*Note:*Rearrangement is involved in each reaction)   **(11 marks)**

i)

i) H_3PO_4 /Δ

ii) H_2O

?

ii)

i) KOH

ii) HBr

?
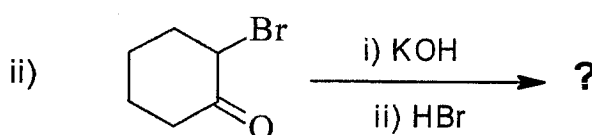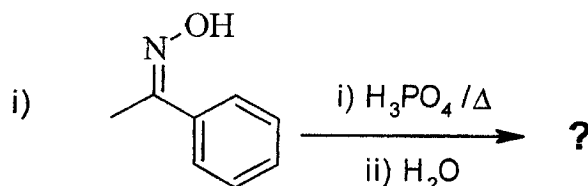
(c)   Bearberry leaf extract is used in skin lightening treatments designed for long term and regular use. The active ingredient of the extract, *arbutin*, is commercially prepared by Koenigs-Knorr reaction:

(R)   **Arbutin**

                                                                 R
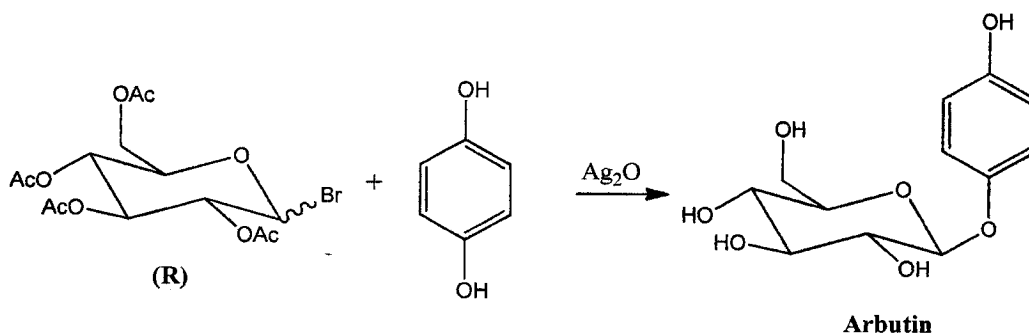
(i)   What classes of compounds are (R) and *arbutin*?   **(2 marks)**

(ii)   Identify the <u>aglycon</u> in *arbutin*.   **(1 mark)**

                                                                                          R
(iii) The reaction follows first order kinetics and both α- and β- anomers of (R) yield *arbutin* in good yield. Propose a mechanistic explanation to account for these results.   **(6 marks)**

QUESTION FIVE

(a) The product of a Dieckmann cyclization can undergo alkylation, hydrolysis, and decarboxylation. This sequence represents an efficient method for preparing 2-substituted cyclopentanones (below) and cyclohexanones. Using this information, propose an efficient synthesis of 2-propylcyclohexanone using 1,7-heptanediol and 1-propanol.
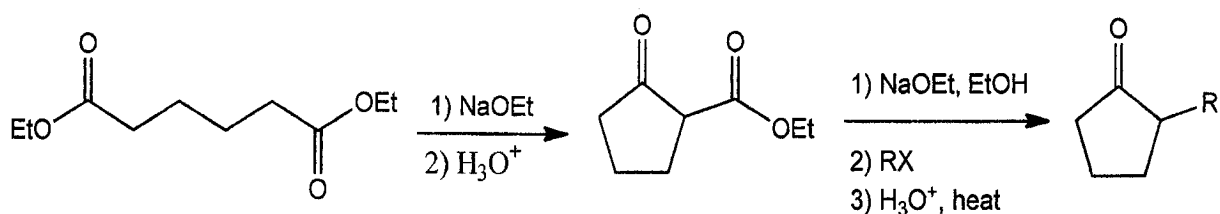
Start by providing a retrosynthetic analysis. **(10 marks)**

(b) (i) Define sigmatropic migration. **(2 marks)**

(ii) Give the two number description for the type of migration present in the example shown below. **(1 mark)**
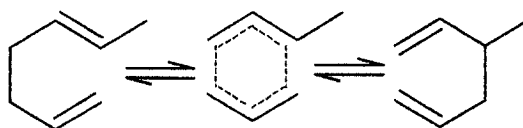
(iii) Which one of the following examples of orbital illustrations **C** and **D** of sigmatropic migration is antarafacial and which one is suprafacial? **(2 marks)**
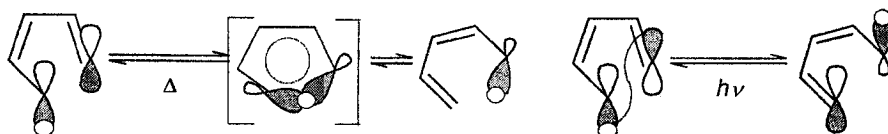
Illustration C   **Illustration D**

(c) Propose a plausible mechanism for the following transformation: **(11 marks)**
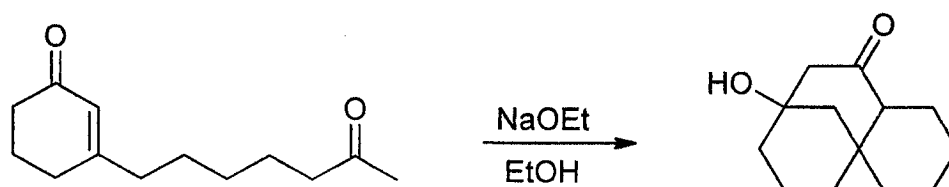
(d) (i) Name two types of possible stereochemistry of straight chain polymers. **(2 marks)**

(ii) Give the name and structure of a catalyst that is frequently used for specific structural conformationsin growth-chain polymerisation? Show the structure of the catalyst.

(2 marks)

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
CHE4422 Examination, 2015

Time: 3 Hours   **July 2015**

Instructions:

Answer any Four (4) Questions.
Periodic Table is provided
Show clarity in your answering.

Question 1

(a) For the cluster $Co_2(CO)_6(CH)_2$, draw its structure?

(b) For the complexes below draw a structure of the expected product of the addition of malonate ion, $CH(COOEt)_2^-$, to the coordinated olefin

    (i) $Pd(C_2H_4)Cl_2(PPh_3)$,   (ii) $Pd(C_2H_4)Cl_3^-$,

(c) Show structures for the following
    (i)   The borane, B_5H_9 while accounting for the hydrogen count.
    (ii)   The carborane, $C_2B_4H_7^-$,
    (iii)   The metalloborane compound, $C_2B_3H_5Fe\,(CO)_3$

Question 2

The character table for the C_6 point group, with $\varepsilon = \exp(2\pi i/6)$, is given below:

C_6	E	C_6	C_3	C_2	$(C_3)^2$	$(C_6)^5$	linear functions, rotations	quadratic functions	cubic functions
A	+1	+1	+1	+1	+1	+1	z, R_z	x^2+y^2, z^2	z^3, $z(x^2+y^2)$
B	+1	-1	+1	-1	+1	-1	-	-	$y(3x^2-y^2)$, $x(x^2-3y^2)$
E_1	+1 +1	$+\varepsilon$ $+\varepsilon^*$	$-\varepsilon^*$ $-\varepsilon$	-1 -1	$-\varepsilon$ $-\varepsilon^*$	$+\varepsilon^*$ $+\varepsilon$	$x+iy$; R_x+iR_y $x-iy$; R_x-iR_y	(xz, yz)	(xz^2, yz^2) $[x(x^2+y^2), y(x^2+y^2)]$
E_2	+1 +1	$-\varepsilon^*$ $-\varepsilon$	$-\varepsilon$ $-\varepsilon^*$	+1 +1	$-\varepsilon^*$ $-\varepsilon$	$-\varepsilon$ $-\varepsilon^*$	-	(x^2-y^2, xy)	$[xyz, z(x^2-y^2)]$

(a) Distinguish the Shapes and the energies of the frontier orbitals for E_1 and E_2 in this point group. Comment on the nature of bonding these frontier orbitals will have with the transition metal centre.

(b) If the student in your class were replace transition metal with a lanthanoid metal, which f-orbitals would be available to bond with E_1 frontier orbitals?

Question 3

(a) Both NiO and ZnO solids are insulators at room temperature. Discuss the effect of increasing temperature on the two oxides.

(b) Rationalise the nature of conduction expected of VO and Y123. Show graphical variation of resistivity with temperature for these oxides.

(c) Changing pressure of S has an effect on how PbS behaves as a semiconductor. Discuss.

Question 4

The **Cativa Process** is a method for the production of acetic acid by the carbonylation of methanol. The technology was developed by BP Chemicals and is under license by BP Plc. The process is based on an iridium-containing catalyst, such as the complex $[Ir(CO)_2I_2]^-$ (1) in the presence HI.
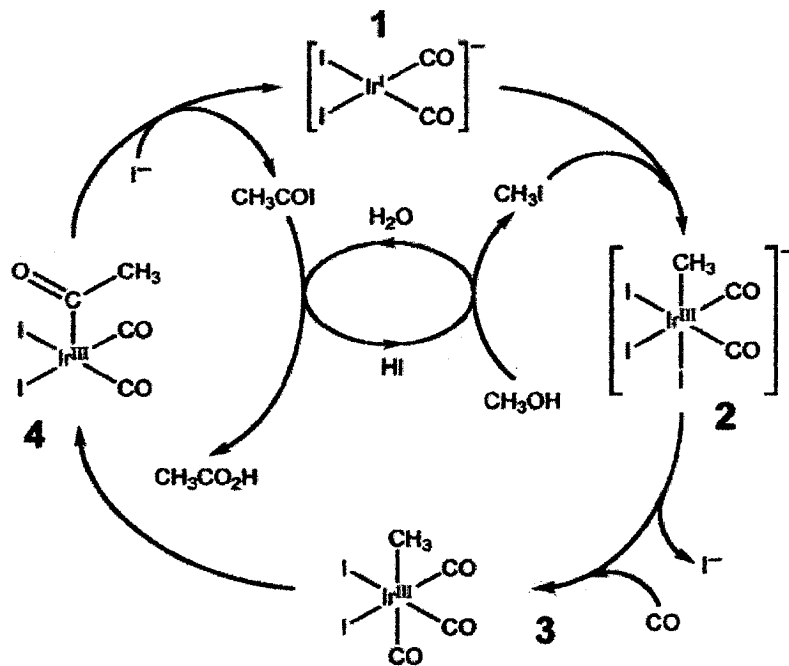
(i) What is the main reaction in the Cativa Process?
(ii) Account of what is happening from **(4)** to **(1)**.
(iii) Explain and identify migratory insertion reaction above.

Question 5

(a) With a clear example, explain what you understand by 'Agostic bonding'and when does it occur.

(b) Green, Davies and Mingos developed rules that help in determining the nature of product for nucleophilic attack in organometallic chemistry. Outline these rules with examples.

(c) The stereochemistry in a electropohilic attack on ligand in organometallic chemistryis dependent on the nature of the intermediate transition state. Discuss.

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic number
X
Atomic mass
Name of the element X

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	1 **H** 1.01 Hydrogen																	2 **He** 4.00 Helium
	3 **Li** 6.94 Lithium	4 **Be** 9.01 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
	11 **Na** 23.00 Sodium	12 **Mg** 24.31 magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.99 Phosphorus	16 **S** 32.07 Sulphur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
	19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.88 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.65 Copper	30 **Zn** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 71.61 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
	37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** 97.91 Technetium	44 **Ru** 101.07 Ruthenium	45 **Rh** 102.91 Rhodium	46 **Pd** 106.42 Palladium	47 **Ag** 107.87 Silver	48 **Cd** 112.41 Cadmium	49 **In** 114.82 Indium	50 **Sn** 118.71 Tin	51 **Sb** 121.76 Antimony	52 **Te** 127.60 Tellurium	53 **I** 126.90 Iodine	54 **Xe** 131.29 Xenon
	55 **Cs** 132.91 Cesium	56 **Ba** 137.33 Barium	57 – 71	72 **Hf** 178.49 Hafnium	73 **Ta** 180.95 Tantalum	74 **W** 183.84 Tungsten	75 **Re** 186.21 Rhenium	76 **Os** 190.23 Osmium	77 **Ir** 192.22 Iridium	78 **Pt** 195.08 Platinum	79 **Au** 196.97 Gold	80 **Hg** 200.59 Mercury	81 **Tl** 204.38 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 208.98 Bismuth	84 **Po** 208.98 Polonium	85 **At** 209.99 Astatine	86 **Rn** 222.02 Radon
	87 **Fr** (223.02) Francium	88 **Ra** 226.03 Radium	89 – 103	104 **Unq** 261.11	105 **Unp** 262.11	106 **Unh** 263.12	107 **Uns** 262.12	108 **Uno** 265.00	109 **Une** 265									

Lanthanides (57 – 71)

57 **La** 138.91 Lanthanum	58 **Ce** 140.12 Cerium	59 **Pr** 140.91 Praseodymium	60 **Nd** 144.24 Neodymium	61 **Pm** 144.91 Promethium	62 **Sm** 150.36 Samarium	63 **Eu** 151.97 Europium	64 **Gd** 157.25 Gadolinium	65 **Tb** 158.93 Terbium	66 **Dy** 162.50 Dysprosium	67 **Ho** 164.93 Holmium	68 **Er** 167.26 Erbium	69 **Tm** 168.93 Thulium	70 **Yb** 173.04 Ytterbium	71 **Lu** 174.97 Lutetium

Actinides (89 – 103)

89 **Ac** 227.03 Actinium	90 **Th** 232.04 Thorium	91 **Pa** 231.04 Protactinium	92 **U** 238.03 Uranium	93 **Np** 237.05 Neptunium	94 **Pu** 244.0 Plutonium	95 **Am** 243.06 Americium	96 **Cm** 247.07 Curium	97 **Bk** 247.07 Berkelium	98 **Cf** 251.08 Californium	99 **Es** 252.08 Einsteinium	100 **Fm** 257.10 Fermium	101 **Md** 260 Mendelevium	102 **No** 259.10 Nobelium	103 **Lr** 262.11 Lawrencium

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

CHE 4522
PHYSICAL ORGANIC CHEMISTRY AND NATURAL PRODUCTS CHEMISTRY

TIME ALLOWED: THREE (3) HOURS

INSTRUCTIONS:

1. This paper contains five questions and has 7 printed pages. Ensure you have all printed pages.

2. Answer any FOUR (4) questions.

3. Each question carries 30 marks.

4. Answer questions in separate booklets as follows:

   (a) Question number 1 and question number 2 in one booklet;

   (b) Question number 3 and question number 4 in one booklet; and

   (c) Question number 5 in one booklet

5. Submit all three booklets tied as one.

QUESTION ONE

(a) The hydrolysis of ethyl benzoates by hydroxide ion in 85% aqueous ethanol gave a reaction constant, $\rho = 2.56$. Calculate how much faster ethyl 4-nitrobenzoate will undergo base-catalyzed hydrolysis than ethyl benzoate under similar conditions.
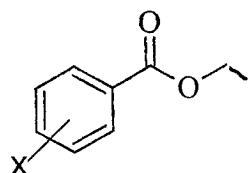
Substituted ethyl benzoate   Ethyl 4-nitrobenzoate   **(5 marks)**
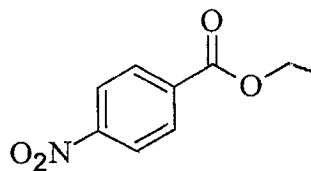
(b) Experimental studies of the hydrolysis of compound **A** in moist acetonitrile (a neutral nucleophilic reagent system) a ρ of 1.20 was obtained from a σ plot. When the same studies were conducted in the presence of perchloric acid (an acidic and highly polar reagent system), a correlation with σ^+ with a ρ equal to -3.90 was found. Explain these observations.   **(10 marks)**
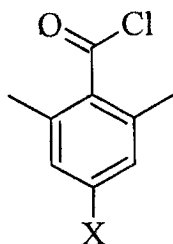
Compound A

(c) Interpret the following σ values in terms of the electronic character of each substituent. Discuss and explain the inductive and resonance effects, showing the resonance forms.

	Substituent	σ_m	σ_p
i)	$CH=CH-NO_2$	0.32	0.26
ii)	OCF_3	0.40	0.35

(4 marks each)

(d) (i) At pH 9.92, the sensitivity, ρ, of ionisation of phenol is 2.25 at 25^0C. Estimate the pK$_a$ value of p-nitrophenol at $25°C$.   **(5 marks)**

(ii) State the Hammond postulate.   **(2 marks)**

2

QUESTION TWO

(a) (i) Draw an energy profile diagram for a primary kinetic isotopic effect. Indicate clearly on the diagram the energy levels and their respective energy differences.

(4 marks)

(ii) In the Cannizzaro reaction of benzaldehyde, the second H-atom attached to the benzyl alcohol comes from the second molecule of benzaldehyde and not from the solvent H_2O. Provide evidence to this fact. **(4 marks)**

(b) Ethyl acetate and sodium hydroxide in equal molar concentrations of **0.1M** in water react with a rate constant of $k = 0.11 \ M^{-1}s^{-1}$ to form acetate anion and ethanol, the reaction is shown below.

$$CH_3COOEt + \ ^-OH \longrightarrow CH_3COO^- + EtOH$$
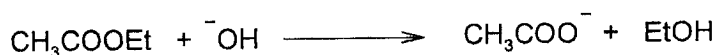
What concentrations of reactants and products would you expect to remain after?

(i) 10 seconds. **(5 marks)**

(ii) 10 minutes. **(5 marks)**

(c) (i) Write the Swain-Scott equation and provide the meaning of each term. **(2 marks)**

(ii) The following reaction proceeds by the S_N2 mechanism with a rate constant,

$k = 0.12 \ M^{-1}s^{-1}$.
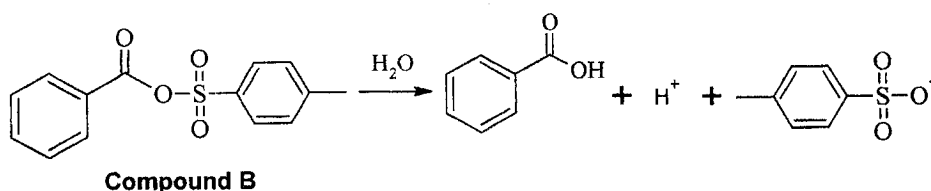
Compound B

If the H_2O were replaced with N_3^- as a nucleophile, at what rate would you expect the reaction to proceed? The substrate constant for compound **B** is 0.66 and the nucleophilic constant for the N_3^- anion is 4.0. **(5 marks)**

(d) Write the Grunwald-Winstein equation and interpret meaning of the proportionality constant and the solvent parameter. **(5 marks)**

QUESTION THREE

(a) Experiment data on a disaccharide C, $C_{12}H_{22}O_{11}$, found in yeast, fungi, algae and insects, is given below:

    (i)   Hydrolysis of C by acid or α-glucosidase gives only D-glucose.
    (ii)   C gives negative Benedict's and Tollen's tests and does not mutarotate.
    (iii)   Exhaustive methylation of C followed by acidic hydrolysis of the methylated product yields two molar equivalents of 2,3,4,6-tetra-*O*-methyl-D-glucose.

    Interpret the data and deduce the structure of C.   **(10 marks)**

(b) State the principal metabolic pathway used by plants to derive the following secondary metabolites.   **(2 marks)**

    (i)   Terpenoids
    (ii)   Isoquinoline alkaloids

(c) Using disconnection approach, devise a synthesis of the bioactive alkaloid **D**, shown below, from N-methyl indole. Assume that catechol (1,2-dihydroxybenzene) and other needed reagents are available. Show the retrosynthetic analysis and all steps of your proposed synthesis, including the intermediates, clearly.

D
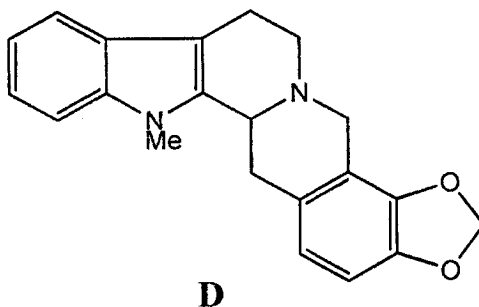
                          (18 marks)

(a) The last three steps in the biosynthetic pathway of the alkaloid isothebaine in a poppy family plant that grows in China are shown below:
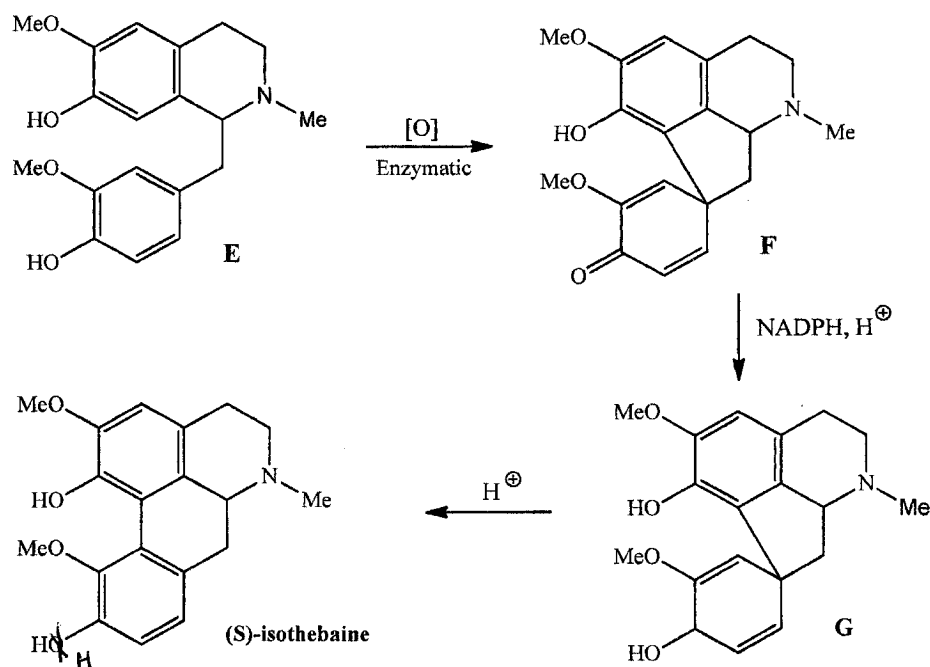
Tracer studies indicate that oxidative phenol coupling and dienol- benzene rearrangement are involved in the pathway shown above. On this basis, provide a mechanistic explanation for:

(i)   transformation of **E** into **F**   **(7 marks)**

(ii)   formation of (S)-isothebaine from **G**   **(5 marks)**

(b) The bioactive alkaloid **H** (an antispasmodic and vasodilator drug) is derived in plants from tyrosine. Based on this information, suggest a biogenetic pathway for **H**, showing all steps clearly.   **(10 marks)**

Alkaloid H

5
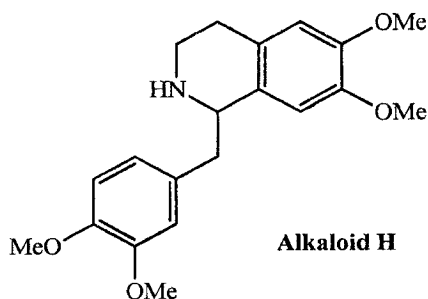
(c) Attempted Hofmann degradation of the alkaloid **J** with excess methyl iodide and aqueous sodium hydroxide <u>unexpectedly</u> gave a compound **L** in good yield. The spectroscopic evidence indicates that reaction proceeds via the intermediate **K**. On this basis, suggest a plausible mechanistic explanation to account for formation of unexpected product **L** from **J**.   **(8 marks)**

Alkaloid J   Intermediate K   Unexpected product L
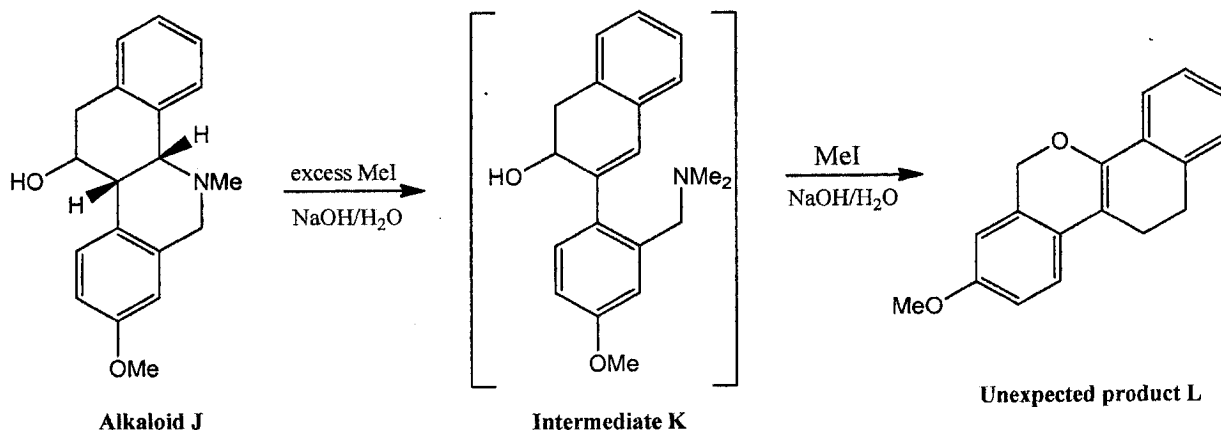
QUESTION FIVE

(a) Consider the synthesis of an alkaloid **R**, shown below:
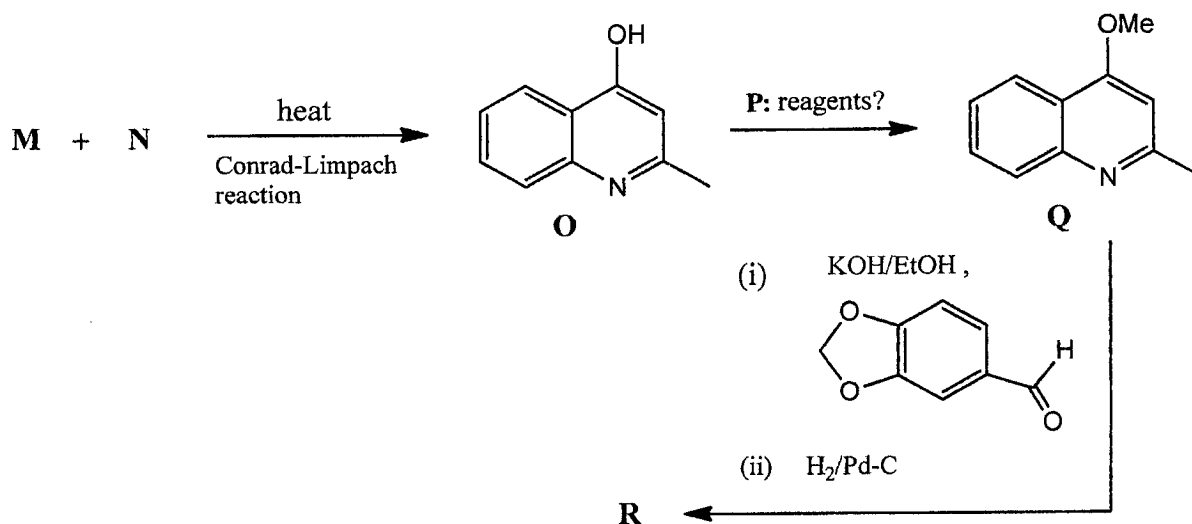
(i) Provide the starting materials and the missing reagents for the above synthesis. (*advice*: Do not write the reactions)   **(5 marks)**

(ii) Deduce the structure of the alkaloid **R**.   **(3 marks)**

6

(b) The following transformation can be achieved in three steps:
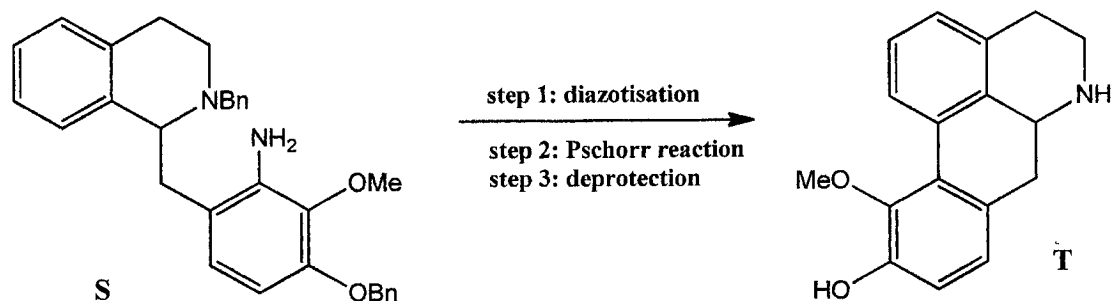
Provide the reagents and conditions for each step. <u>The intermediates/reactions are **not** required to be shown.</u>   **(5 marks)**

(c) Periodic acid oxidation of a glucose derivative, **X**. required 4 molar equivalents of periodic acid and gave 3 moles of formic acid, 1 mole of formaldehyde and 1 mole of OHC-COOH. What is the structure of **X**?   **(3 marks)**

(d) The relative rates of alkaline hydrolysis of substituted benzamides in water at 100^0C are as follows.

Substituent-X	Relative Rate	σ- values	Substituent-X	Relative Rate	σ- values
m-I	2.60	0.35	*m*-CH₃	0.83	-0.07
m-Br	2.97	0.39	*p*-CH₃	0.65	-0.17
p-Br	1.91	0.23	*p*-OCH₃	0.49	-0.27
m-NO₂	5.60	0.71	*m*-NH₂	0.93	-0.16
H	1.00	0.00	*m*-OH	0.19	0.12

(i) Demonstrate graphically, the applicability of the Hammett equation to this reaction and determine its ρ–value. Comment on the validity of the equation by comparing the obtained ρ–value with the ρ–value calculated from the equation. (*NOTE: Use the graph paper you have been provided with for this question*)
   (10 arks)

(ii) Explain briefly why the substituent *m*-OH shows a **large** deviation from the linear correlation.   **(4 marks)**

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY

2014/15 ACADEMIC YEAR MID-YEAR FINAL EXAMINATIONS

CHE 4811
INORGANIC INDUSTRIAL CHEMISTRY

Duration: THREE (3) HOURS

INSTRUCTIONS TO THE CANDIDATES:

1. THIS PAPER CARRIES 100 MARKS AND HAS A TOTAL OF SIX (6) QUESTIONS.
2. EACH QUESTION CARRIES 20 MARKS.
3. QUESTION NUMBER 1 (No. 1) IS COMPULSORY.
4. ANSWER A TOTAL OF 5 QUESTIONS ONLY.
5. ANSWER EACH QUESTION IN A SEPARATE ANSWER BOOKLET PROVIDED.

QUESTION 1

a) A standard grain size analysis test was carried out in order to determine the relative proportions of different grain sizes as they are distributed among certain size ranges. The following results were obtained in the table shown below.

sieve #	Sieve size mm	% mass Retained	Cumulative % retained	% finer
4	4.75	154		
8	2.36	72		
16	1.18	72		
30	0.6	141		
40	0.425	85		
50	0.30	80		
100	0.15	149		
200	0.075	45		
Pan		24		

    i. Give that the mass of sample - Wt = 824g, copy and complete the table of results provided for you. Show only one sample calculation for each column.

(4 marks)

    ii. Use the data in the table above to plot a graph on the graph paper provided for you (sieve size vs. % finer).

(8 marks)

b) Calculate the total % mass loss during this sieve analysis?

(4 marks)

c) From the graph, obtain diameters Corresponding to 10%, 30% and 60% finer. Label your lines clearly in ink on your graph.

(4 marks)

QUESTION 2

a) List three grinding laws and express each of these in terms of half empirical models used for different particle size.

(6 marks)

b) Describe the mechanism of operation for the Vertical shaft impactor crusher.

(4 marks)

c) A material is crushed in a Blake jaw crusher (The work index -12.74) so that the average size of particles is reduced from 50 mm to 10 mm, with the consumption of energy of 13.0 kW. Calculate the energy needed to crush material of average size 75 mm to average size of 25 mm based on:

a) Rittinger's law. (4 marks)

b) Kick's law. (4 marks)

c) Which of the results would you regard as being more reliable?

(2 marks)

QUESTION 3

a) Explain how grinding results can be evaluated in terms of Grinding degree by referring to grain size and specific surface area.

(6 marks)

b) What is the power required to crush 100 ton/h of limestone if 80% of the feed pass a 5.1 cm screen and 80% of the product 0.3 cm screen? The work index for limestone is 12.74.

(6 marks)

c) Sketch a Dodge type jaw and describe the mechanism of operation.

(8 marks)

QUESTION 4

a) What is the difference between laminar and turbulent flow, and briefly explain the transitions that are expected when a well ordered flow of a fluid is intensified.

(4 marks)

b) Consider a Laminar boundary layer over a flat plate. Sketch the velocity profile as a function of the distance from the plate surface, du/dy. Express shear strain γ in terms of the rate of shear strain.

(8 marks)

c) The flow rate of a liquid is 4 M^3/s and the cylindrical pipe in which the fluid flows has a diameter of 6cm. Determine the Reynolds number for the fluid which has a density of 1268 kg/m^3 and the viscosity is 17 Pa.s, and in addition indicate the flow regime (Laminar/Turbulence).

(8 marks)

QUESTION 5

a) Briefly describe the operation principle of the sharp edged orifice.

(4 marks)

b) Account for how you would use a Pitot static tube to measure the volume flow rate in a turbulent pipe flow.

(8 marks)

c) A Pitot tube can be used to determine the velocity of air flow by measuring the difference between the total pressure and the static pressure. If the fluid in the tube is mercury, density $\rho_{Hg} = 13.6$ kg/m^3 and $\Delta h = 5.0$cm, find the speed of air flow. Assume that the air is stagnant at point A and take $\rho_{air} = 1.25$ kg/m^3.
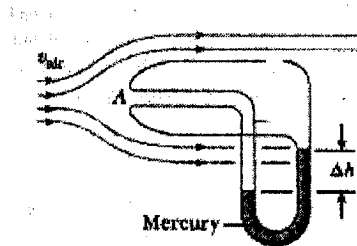
(8 marks)

QUESTION 6

a) Briefly describe the concept of Theoretical volumetric flow rate and the Discharge Coefficient. Make reference to at least one real situation where it may have relevance.

(4 marks)

b) A Venturi Meter is a device that allows flow rates through pipes to be calculated by measuring the difference in pressure created by a contraction in a pipe. By using a sketch show how the given equation below is derived.

$$P_1 - P_2 = gh_p(\rho_m - \rho)$$

(8marks)

c) The air supply to an engine on a test bed passes down a 180 mm diameter pipe fitted with an orifice plate 90 mm diameter. The pressure drop across the orifice is 80 mm of paraffin. The coefficient of discharge of the orifice is 0.62 and the density of air and paraffin are 1.2 kg/m^3 and 830 kg/m^3 respectively. Calculate the mass flow rate of air to the engine.

(8 marks)

END OF EXAM

4

DATA TABLE FOR QUESTION 1

sieve #	Sieve size mm	% mass Retained	Cumulative % retained	% finer
Pan				

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF CHEMISTRY

2014/15 ACADEMIC YEAR - END OF YEAR EXAMINATIONS

CHE 4822
INORGANIC INDUSTRIAL CHEMISTRY

Duration: THREE (3) HOURS

<u>INSTRUCTIONS TO THE CANDIDATES:</u>

1. THIS PAPER CARRIES 100 MARKS AND HAS A TOTAL OF SIX (6) QUESTIONS.
2. EACH QUESTION CARRIES 20 MARKS.
3. ANSWER ANY FIVE QUESTIONS.
4. ANSWER A TOTAL OF 5 QUESTIONS ONLY.
5. ANSWER EACH QUESTION IN A SEPARATE ANSWER BOOKLET PROVIDED.

1.

A triple effect forward feed evaporator is being used to evaporate a sugar solution containing 10 wt % solids to a concentrated solution of 50%. Saturated steam at 205.5 kpa, 121.1°C saturation temperature is being used. The pressure in the vapour space of the third effect is 13.4 kpa. The feed rate is 22 680 kg/h at 26.7 °C. Given that the heat of the solution is negligible and that each effect has the same surface area.

a) Calculate the total amount of the vapour stream and the liquid stream leaving the third evaporator unit (III). **(8 marks)**

b) Write a material balance for solids and hence show that X_3 = 0.500. **(6 marks)**

c) Describe the mechanism of operation for Triple Effect Back-Ward feed evaporator. Use a sketch to illustrate. **(6 marks)**

2.

a) The manufacturing process of Superphosphate depends on reacting phosphate rock with sulphuric acid and the fertilizer contains about (16 - 20 %) P_2O_5. The net reaction proceeds as follows:

$$2Ca_5F (PO_4)_3 + 7H_2SO_4 + 3H_2O \rightarrow 3Ca (H_2PO_4)_2 . H_2O + 7CaSO_4 + 2HF$$
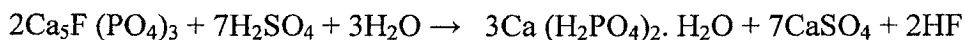
The process can be divided into two stages, explain briefly what each stage represents.
(12 marks)

b) With the aid of a Flow Diagram describe the manufacturing process for the Single Superphosphate Fertilizer. **(4 marks)**

c) With the aid of a Flow Diagram describe the manufacturing process for the Triple Superphosphate Fertilizer. **(4 marks)**

3.

a) Briefly describe the Wet – process Phosphoric acid manufacture. **(6 marks)**

b) With the aid of a Flow Diagram, illustrate the manufacturing process of Phosphoric acid Wet - process. **(8 marks)**

c) Use a sketch to illustrate the mechanism of operation for the Bird-Prayon Tilting – Pan Filter for the phosphoric acid manufacture. Indicate clearly the source of the Weak water liquor and explain its importance. **(8 marks)**

4.

a) You are told that in a particular case of fluid flow over a flat plate the temperature boundary layer thickness is much smaller than the velocity boundary layer thickness. What can you conclude about the nature of the fluid? **(4 marks)**

b) The inner and outer surface temperatures of a glass window 5 mm thick are 15 and 5°C, respectively. What is the heat loss through a window that is 1 m by 3 m on a side? The thermal conductivity of glass is 1.4 W/mK. **(8 marks)**

c) Air at 300°C flows over a flat plate of dimensions 0.50 m by 0.25 m. If the convection heat transfer coefficient is 250 W/m^{2}K, determine the heat transfer rate from the air to one side of the plate when the plate is maintained at 40°C. **(8 marks)**

5.

a) With the aid of a Flow Diagram describe the Manufacturing Process of Sulphuric Acid. **(8 marks)**

b) Briefly describe the oxidation of SO_2 to SO_3 process (Indicate Kindling and other temperatures if Vanadium catalyst is used). **(8 marks)**

c) Describe the absorption process of SO3 and explain why a second absorption stage is necessary. State the properties of 98.3% Sulphuric acid and why this acid is used for absorption of SO_3 containing gas? **(8 marks)**

6.

a) With the aid of a Flow Diagram describe the Manufacturing Process of Ammonium Nitrate. **(8 marks)**

b) Explain the major function of the post neutraliser units Unit in the Manufacturing process of Ammonium Nitrate. **(4 marks)**

c) The **AS-72** process for the Manufacture of Ammonium Nitrate uses a heat of reaction neutraliser and two evaporation stages. With reference to the flow sheet of the **AS-72** describe the major functions of the Magnesium Nitrate added to Unit 4 and the Prilling Tower - Unit 17. **(12marks)**
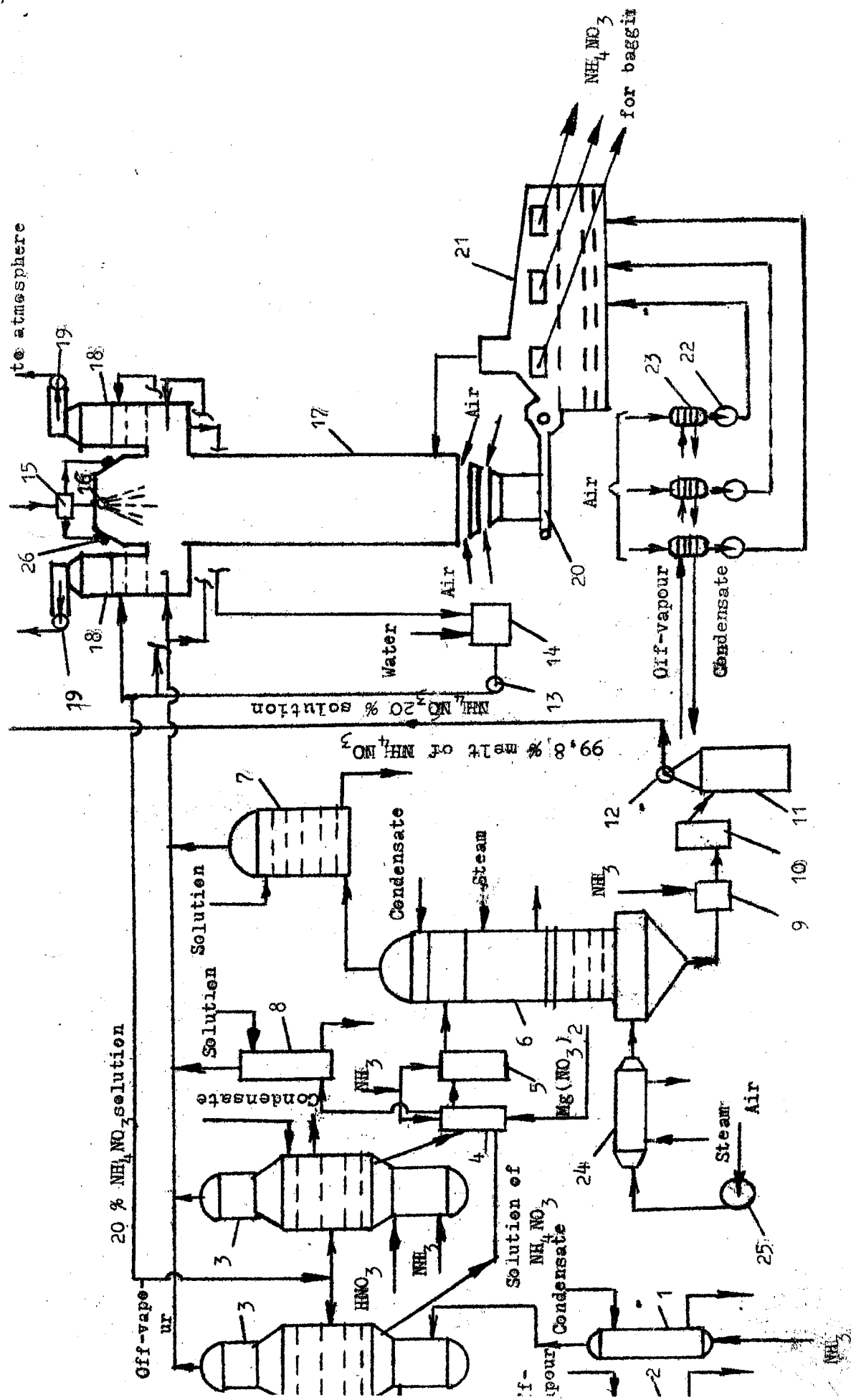
Flowsheet of the Ammonium Nitrate Unit:

ammonia preheater; 2, acid preheater; 3, heat-of reaction neutralizer; 4,5, post-neutralizers; 6,evaporator; 7,8,18, ubbers; 9, hydraulic-seal-post-neutralizer; 10, melt filter; 11, melt tank; 12,13, pumps; 14, collector;of NH_4NO_3 ations; 15, constant-head tank; 16, ultrasonic spray nozzle; 17, prilling tower; 23,24, air preheaters; 25, air

The University of Zambia Examination 2015
School of Natural Science
Digital Electronics CS3120

Time: 3 Hours
Instructions: Answer any 5 questions
All questions carry 20 marks

1.   a) Use Thevrnin's theorem to find the current **I** in the circuit.
          b) Use Norton's theorem to find the current **I** in the circuit.

2Ω

1 A

2Ω

2Ω

4 V

I

2.
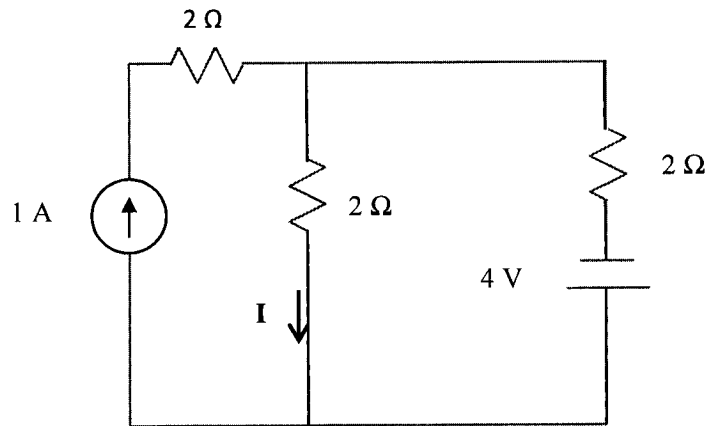
a.   Use Kirchoff's theorem to find the current **I** in the circuit.

7Ω

8Ω

8Ω

4Ω

2Ω

8 V

I
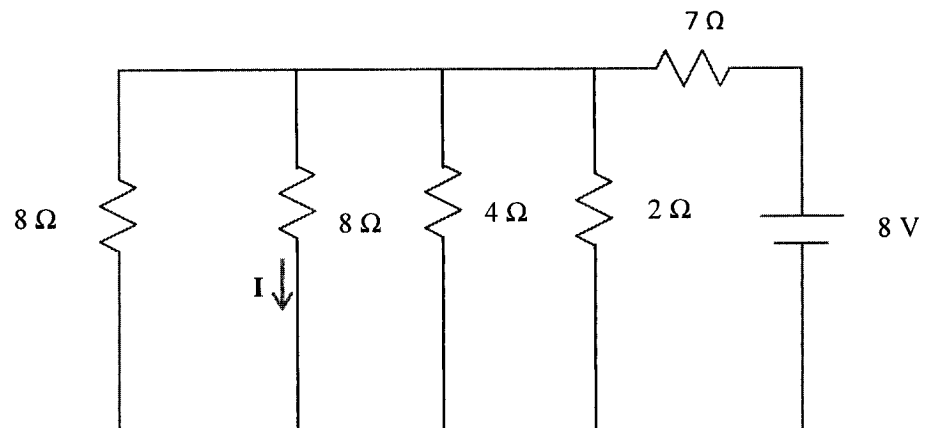
3. Use Nodal analysis to find the current **I** in the circuit.
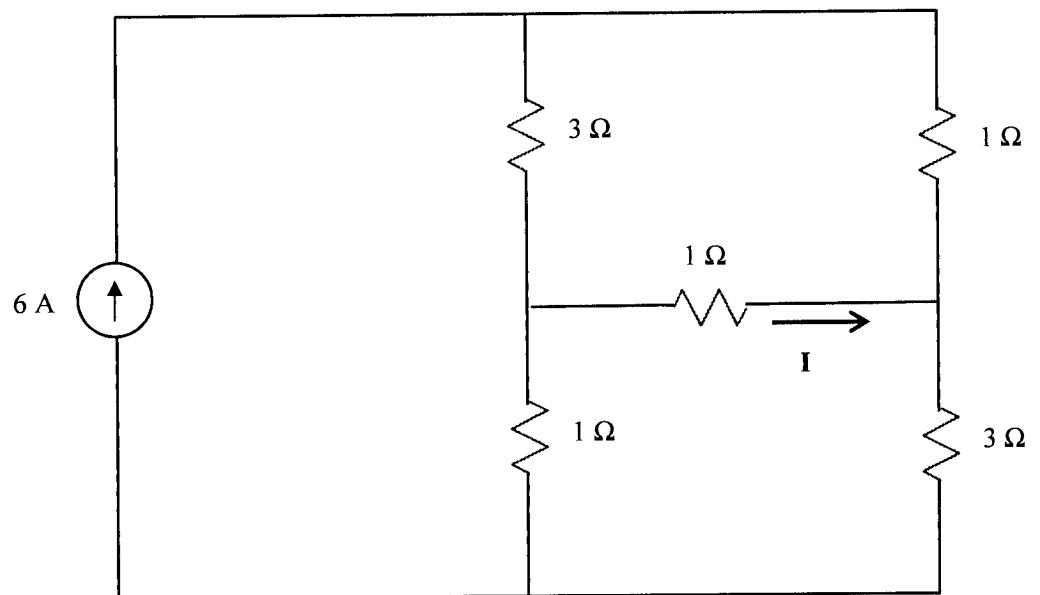
4.

   a. Using De Morgan's theorem and Boolean algebra, prove that the two circuits shown are equivalent.
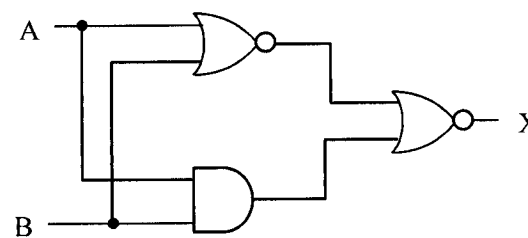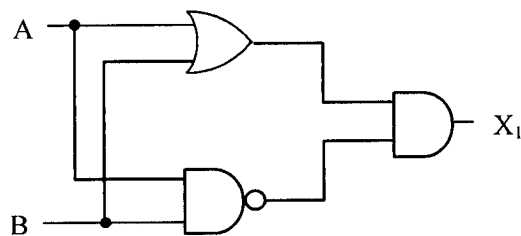
   b. Prove that the two circuits are an implementation of an XOR (Exclusive OR)

5.

    a. Design a circuit that outputs a HIGH when the binary value of ABCD (D is LSB) is < 10. Draw the circuit.

    b. Implement the circuit using only NAND gates.

6.   Simplify the circuit using

    a. Demorgan's theorem and Boolean algebra.

    b. Confirm the result in part a. by using K-maps to simplify the circuit.
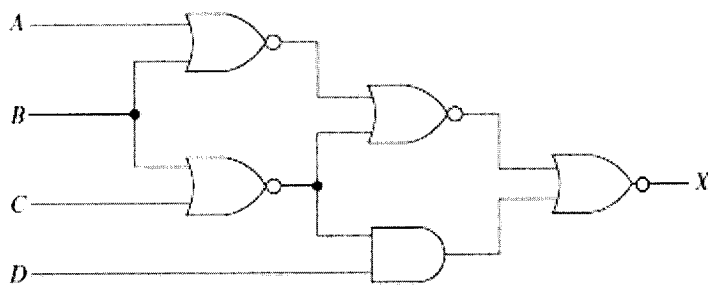
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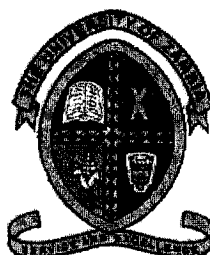
THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Studies

COMPUTER PROGRAMMING
CSC 2000

2014-2015 FINAL EXAM

Date: 26th June 2015
Venue: API
Time: 09:00hrs – 12:00hrs
Duration: 3 Hours

Instructions

1. This exam has two (2) sections

2. Answer **all** questions in section A

3. Section B has three **three(3)** questions, answer any **two (2)** questions

SECTION A

Answer all the questions in this section [50 Marks]

1. Analyze the code below and answer the questions that follows;

```
public abstract class Peron{
  private String name;
  private String nationality;
  private int age;

  public Person(String name, int age){
    this.name = name;
    this.age = age;
    nationality = "Zambian";
  } //end constructor

  public void computeSalary(){
    double salary = age/0.5;
    System.out.println(salary);
  }//end method

  public abstract void printInfor();

}//end class
```

a) Define the concepts Inheritance and Polymorphism. [2 Marks]

b) Write a class called Jonathan than inherits from the Person class above. Jonathan must override the ComputeSalary method and calculate the salary as age divide by 0.1 and print the result. The Jonathan class must also override the abstract method and print the name, nationality and age. [10 Marks]

c) Write a class called PersonTest with the main method. The class should create three Jonathan objects. You should then call the objects created to print the information they carry. [5 Marks]

d) Demonstrate the concept of polymorphism using Jonathan and the Person class [8 Marks]

2. Explain the following java concepts and give example code in java to demonstrate the concept.

    a) Exception handling [5 Marks]
    b) Interface [5 Marks]
    c) Event handling [5 Marks]
    d) Arrays [5 Marks]
    e) Objects [5 Marks]

SECTION B

Answer any two (2) questions of your choice. Each question is worth 25 marks.

1. Write a program in Java that checks if a number is a multiple of 3. Example; A multiple of 3 is a number that 3 can go into without leaving a remainder. Your program must use the graphical user interface (GUI) for both getting input from the user and displaying the results. [25 Marks]

2. Analyze the java code given below;

```
public class A{

    public static void main(string args){

        for(int i=0; i => 10; i++){
            if(i == 2){
                continue
            }
            System.out.print("i");
        }
    }
}
```

   a) What syntax errors will the above code generate when compiled? [5]
   b) Write the correct code without compilation errors [2]
   c) Assuming you have corrected the error(s), what will be the output? [3]
   d) Rewrite the class A using the while loop [5 Marks]
   e) Rewrite the class A using the do while loop [5 Marks]
   f) Define the following;
      i. Attribute [1 Mark]
      ii. Class [1 Mark]
      iii. Primitive data type [1 Mark]
      iv. Reference data type [1 Mark]
      v. Method [1 Mark]

3. On Friday 14th November 2014, UNZA students rioted for BC payment and poor sanitations in the male hostels. The police used teargas to contain the situation. The teargas was too much making some students faint. A teargas has a date of expiry, amount of chemicals inside, weather its explosive or not and manufacturer's name. It can do the following; release gas and burn rooms.

<u>Task</u>

Represent teargas as a class in java. Include all its attributes and behaviors. Choose the appropriate data types for the attributes and for simplicity in its behaviors, just write a statement that prints the name of the behavior to the console. For each attribute, include the set and get methods. Clearly format and comment your code. [25 Marks]
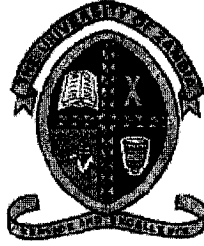
THE UNIVERSITY OF ZAMBIA

School of Natural Sciences

Department of Computer Studies

<u>END OF YEAR - FINAL EXAMINATION</u>

INTRODUCTION TO ARTIFICIAL INTELLIGENCE
CSC 3402

Date: TUESDAY, 30TH JUNE 2015

Time: 09:00hrs – 12:00hrs

Duration: 3 Hours

Venue: GLT

<u>Instructions</u>

a) *There are SEVEN (6) questions in this paper and you are required to answer ANY FIVE (5) OF THEM IN ANY ORDER.*

b) *All questions have carry the weight of 20 marks each*

c) *Each question should start on its separate page or booklet*

1.
  a. Define the following
     i.   Agent [2 Marks]
     ii. Rational agent [2 Marks]
  b. Describe any four types of agents [8 Marks]
  c. Write an algorithm that describes the depth-first search procedure [8 Marks]

2.
  a. Describe the four ways used to evaluate the performance of a search algorithm. [8 Marks]
  b. Evaluate the performance of the following search algorithms using the criteria described above (b – branching factor, d – depth of the search tree)
     i.   Depth-first search [4 Marks]
     ii. Breadth-first search [4 Marks]
  c. Consider the search tree below.
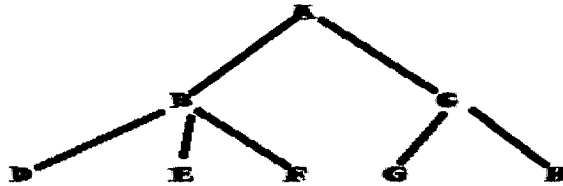
  Show the order in which the nodes are visited starting from the root the goal is H, in
     i.   BFS [2 Marks]
     ii. DFS [2 Marks]

3.
  a. Define what a local search algorithm is and when such algorithms are used. [5 Marks]
  b. For each of the local search algorithms below explain what is and how it operates
     i.   Hill-climbing [5 Marks]
     ii. Simulated annealing [5 Marks]
     iii. Genetic algorithms [5 Marks]

4.
  a. Define the following:
     i.   Admissible heuristic [3 Marks]
     ii. Optimistic heuristic [3 Marks]
  b. A* is an informed search that uses heuristics in its evaluation function. Show that if the heuristic is admissible, then the A* search will be optimal [8 Marks]

  c. Consider the following evaluation function:
  f(n) = (2-k)*g(n) + k*h(n) where g is the cost from the start to n and g is the heuristic function. Which search algorithm do you get for the following values of k
     i.   k = 0 [2 Marks]

1

ii. k = 1 [2 Marks]

iii. k = 2 [2 Marks]

5. Given below is partial search tree for a two player game with leaves at the depth of 3.
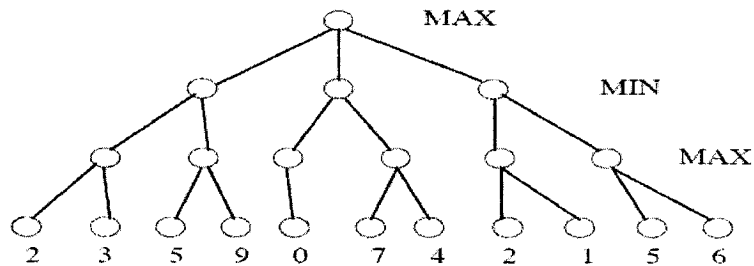
a. Show, using the MINIMAX procedure, which move is played next by MAX player. Show how the values are cascaded to the root[8 Marks]

b. Using alpha-beta pruning show which parts of the tree do not need to be searched by indicating where the cuts occur. [12 Marks]

6.

a. Describe the following heuristics in constraint satisfaction problems and what they are used for

i. Most constrained variable (Minimum remaining values) [2 Marks]

ii. Most constraining variable [2 Marks]

iii. Least constraining value [2 Marks]

b. Consider the following sketch below which should be painted it in such a way that no two adjacent regions (sharing a boundary) have the same colour. There are only three colours available, red, green, and blue (Alphabetical order can be used as a tie breaker if none of the heuristics work)
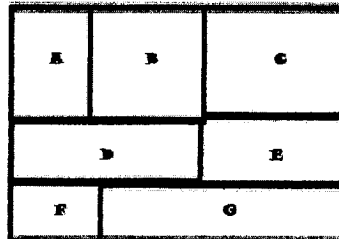
i. Draw the constraint graph. [4 Marks]

ii. Assign the values to the regions applying the heuristics and arc-consistency in choosing the order of assigning and the value to be assigned next. (Show the steps) [10 Marks]

****************END OF EXAMINATION******************

2
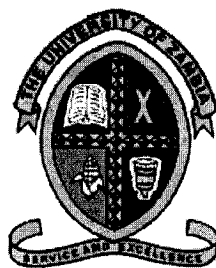
THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Studies

IT PROJECT MANAGEMENT
CSC 3612

2014-2015 FINAL EXAM

Date: 1st July 2015
Venue: G3
Time: 09:00hrs – 12:00hrs
Duration: 3 Hours

Instructions

1. *This examination has two sections*
2. *Answer all questions in Section A. Each question carries 5 marks*
3. *Answer any three questions in Section B. Each question carries 20 marks*

Section – A   **8 x 5 = 40 Marks**

Answer all the questions. Each Question carries 5 Marks

1. What is Project Management? Explain different knowledge areas in PM?

2. What is the role and suggested skills for Project Manager?

3. Explain about different product life cycle?

4. Explain about Integrated change control?

5. Briefly explain the main processes in Project Time Management?

6. Define cost estimating? Explain different types of cost estimates?

7. Explain the testing in Project Quality Management?

8. Create a weighted scoring model to determine grades for a course. Final grades are based on three exams worth 15%, 20%, and 25%, respectively; homework is worth 20%; and a group project is worth 20%. Enter scores for three students. Assume Student 1 earns 100% (or 100) on every item. Assume Student 2 earns 80% on each of the exams, 90% on the homework, and 95% on the group project. Assume Student 3 earns 90% on Exam 1, 75% on Exam 2, 80% on Exam 3, 90% on the homework, and 70% on the group project. Find out which student got highest weight?

Section – B   **3 x 20 = 60 Marks**

Answer any 3 questions. Each Question carries 20 Marks.

1. a. What is a Project Charter? What is the format to develop a project charter? **[8 Marks]**

   b. What is a project management plan? Explain in detail about the common elements of a project management plan? **[12 Marks]**

2. a. Create a WBS for creating a new information system for your school **[7 Marks]**

   b. Describe different ways to develop a WBS and explain why it is difficult to do **[6 Marks]**

   c. Give some advice for creating a WBS and WBS dictionary **[7 Marks]**

3. Write short notes

   a. Gantt Charts [5 Marks]

   b. Critical Chain Scheduling [5 Marks]

   c. PERT [5 Marks]

   d. Critical Path Method [5 Marks]

4. a. Explain about earned value management and its terms [10 Marks]

   b. Given the following information for a one-year project, answer the following questions.

Planned Value (PV)	= $35,000
Earned Value (EV)	= $30,000
Actual Cost (AC)	= $40,000
Budget at completion (BAC)	= $150,000

   i) What is the cost variance, schedule variance, cost performance index (CPI), and schedule performance index (SPI) for the project [2 Marks]

   ii) How is the project doing? Is it ahead of schedule or behind of schedule? Is it under budget or over budget? [2 Marks]

   iii) Use the CPI to calculate the estimate at completion (EAC) for this project, Is the project performing better or worse than planned? [2 Marks]

   iv) Use the SPI to estimate how long it will take to finish this project. [2 Marks]

   v) Sketch the earned value chart based for this project. [2 Marks]

5. a. Explain the different processes in Project quality management? [5 Marks]

   b. Explain different tools and techniques in Quality Control? [10 Marks]

   c. Explain in detail about quality assurance plan? [5 Marks]

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Science

FINAL EXAMINATION

CSC 4505
GRAPHIC AND VISUAL COMPUTING

Date: 10th JULY 2015
Time: 14:00hrs – 17:00hrs
Duration: 3 Hours
Venue: Upper Dining Hall

Instructions

1. There are five (5) questions and **two (2) sections** in this paper.
2. *Answer all the questions in Section A and choose any two (2) question from Section B*

SECTION A

ANSWER ALL THE QUESTIONS IN THIS SECTION

Q. 1

a) Define Pixelization and name one other term you can use in its place. (2 marks)

b) The emitted light by phosphor in CRT fades very quickly and the technique is needed to maintain the screen picture. Name and explain it? (3 marks)

c) What is the function of glMatrixMode? (2 marks)

d) Explain how to eliminate a flicker in an Opengl program. (2 marks)

e) How do sophisticated graphics systems, which are becoming increasingly common these days, achieve their great speed? (3 marks)

f) What is a random-scan, calligraphic, or vector CRT device? (2 marks)

g) What is the function of glutMainLoop? (2 marks)

h) Callbacks are used for two purposes, what are the purposes?(2 marks)

i) We can think about input devices in two distinct ways. Name the ways.(2 marks)

Total Marks 20

Q. 2

a) Explain why we need Double Buffering. (2 marks)

b) What is the purpose of the shadow mask in the CRT? (3 marks)

c) What is the purpose of the following: rotation, scaling and translation? (3 marks)

d) What makes the DDA not a very good algorithm of drawing a line and how can we improve its performance? (3 marks)

e) What does the function called glutInitPosition do? (2 marks)

f) How many colors does 8-bit-deep buffer allows? (2 marks)

g) Systems can display sufficient colors to represent most images realistically. Why is it that such systems are called true-color systems, or RGB-color systems? (3 marks)

h) Color CRTs have three different colored phosphors (red, green, and blue), arranged in small groups. What are the arrangements called? (2 marks)

Total Marks 20

SECTION B

ANSWER ANY TWO (2) QUESTIONS IN THIS SECTION

Q. 3

a) Explain the differences between the OpenGL core library, the OpenGL Utility and OpenGL Utility Toolkit. (4 marks)

b) Discuss liquid-crystal displays (LCDs) and plasma panels. (4 marks)

c) Explain briefly the use of computer graphics in the display of information. (4 marks)

d) We can correctly clip a polygon by processing the polygon boundary as a whole against each window edge. This could be accomplished by processing all polygon vertices against each clip rectangle boundary in turn. Write the Sutherland – Hodgeman clipping algorithm. (5 marks)

e) What can you say about the following devices space ball and joystick? (4 marks)

f) Write an OpenGL program which draws the 10 points. (5 marks)

g) Translation is one of the forms of 2D transformation. What do know about translation? (4 marks)

Total Marks 30

Q. 4

a) Scaling is one of the forms of 2D transformation. What do know about scaling? (4 marks)

b) Line drawing is accomplished by calculating intermediate positions along the line path between two specified endpoint positions. Write three line drawings algorithms. (9 marks)

c) Write an OpenGL program which draws the Spinning Teapot. (5 marks)

d) Explain briefly the use of computer graphics in Simulation and Animation. (4 marks)

e) Explain briefly the scan conversion of the simple polygon. (4 marks)

f) Explain in detail the four neighbor polygon filling algorithm. (4 marks)

Total Marks 30

Q.5

   a) Generally, any procedure that identifies those portions of a picture that is either inside or outside of a specified region of space is referred to as a clipping algorithm. Explain briefly about point and line clipping. *(6 marks)*

   b) Explain briefly the use of computer graphics in user interfaces. (4 marks)

   c) The circle is a frequently used component in pictures and graphs, a procedure for generating either full circles or circular arcs is included in most graphics packages. Write two midpoint circle drawing algorithms. (8 marks)

   d) Explain in detail the eight neighbor polygon filling algorithm. (4 marks)

   e) Applications of clipping include extracting part of a defined scene for viewing; identifying visible surfaces in three-dimensional views; creating objects using solid-modeling procedures; and drawing and painting operations that allow parts of a picture to be selected for copying, moving, erasing, or duplicating. Write Cohen and Sutherland clipping algorithm. (4 marks)

   f) Write an OpenGL program which draws the 6 sided polygon. (4 marks)

Total Marks 30

THE END
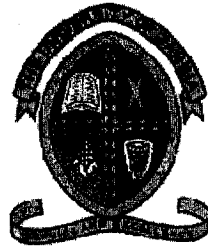
THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Studies

FINAL EXAMINATION

ADVANCED SOFTWARE ENGINEERING
CSC 4630

Date: 25$^{\text{TH}}$ JUNE 2015
Time: 09:00hrs – 12:00hrs
Duration: 3 Hours
Venue: LIBRARY BASEMENT

Instructions

1. *Answer all the questions in Section A.*
2. Choose *any THREE (3) questions from Section B.*

Marks

QUESTION 1

6

    Explain the importance of architectural design

QUESTION 2

    Define the following concepts:

  I.   Black-box testing

3

  II.   White-box testing

3

  III.   Stress testing

3

QUESTION 3

To implement the singleton pattern often (but not always) requires using what other pattern?   **3**

QUESTION 4

What are the contents of a use case?   **4**

QUESTION 5

How do design patterns differ from frameworks?   **6**

QUESTION 6

The testing techniques we discussed during the course were aimed at establishing the functioning of a system. How can you test whether a system meets the following non-functional requirements?

    I. Scalability

                        2

    II. Security

                        2

    III. Performance

                        2

QUESTION 7

What is integration testing?   **4**

QUESTION 8

Determine at which stage assigning of responsibilities occurs

                        2

Total 40 Marks

QUESTION 1   **Marks**

a) What are the different types of stakeholder concern that may arise in a large system? How can aspects support the implementation of each of these types of concern?

10

b) Consider a wrapper whose implementation logs each call that occurs. In no more than 2 sentences each, explain when the wrapper should be considered a decorator (and why), and when that same wrapper should be considered a proxy (and why)

10

Total 20 Marks

QUESTION 2   **Marks**

a) List 4 fundamental questions that should be addressed in architectural design?

4

b) Define what an operation contract is and how is it generated?   **4**

c) Determine at which stage assigning of responsibilities occurs.   **2**

d) State 3 distinct benefits of writing tests before writing the code.   **6**

e) Define what an operation contract is and how is it generated?   **4**

Total 20 Mark

QUESTION 3 **Marks**

a) Draw an UML diagram to show the structure of the Observer Pattern.   **5**

b) What is the basic GOF pattern in MVC? Explain the components of MVC. Observer (Model-View)   **5**

c) Give some typical real life and programming examples to use MVC.   **5**

d) How do you implement this pattern in Java?   **5**

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Total 20 Mar

</div>

QUESTION 4

a) Briefly describe the steps used when testing the CRC Model   10

b) Explain with an example what an Object diagram is   6

c) Explain how domain engineering differs from application engineering 4

Total 20 Mark
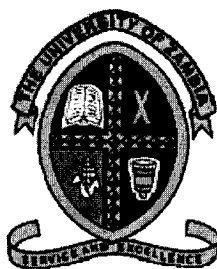
END OF PAPER

THE UNIVERSITY OF ZAMBIA
School of Natural Sciences
Department of Computer Science

FINAL EXAMINATION

DISTRIBUTED SYSTEMS - CSC 4722

Date: Thursday, 9th July 2015
Time: 09:00hrs – 12:00hrs
Duration: 3Hours
Venue: UPPER DINING HALL

Instructions

1. There are six (6) questions and **two (2) sections** in this paper.
2. Each question carries **20 marks,**
3. *You are required to answer a total of **Five (5) Questions***
   a. Answer *all the questions in Section A*
   b. Choose *any three (3) questions from Section B*

SECTION A

This section has Two Question. Answer all the questions

QUESTION I

a) Define each of the following terms [2]
   i.   Distributed Computing
   ii. Remote Method Invocation (RMI)

b) The main goal of a distributed system is to make it easy for the users and applications to access remote resources, and to share them in a controlled and efficient way. Good examples of the resources include things like printers, computers, storage facilities, data, files, web pages, and networks as shown in the diagram below.
   i.   Describe a distributed System in reference to the diagrams below [2]
   ii. Give the four main goals of Distributed Systems [2]
   iii. List any four characteristics of distributed systems that would enable you to achieve the goals above of a distributed system [2]
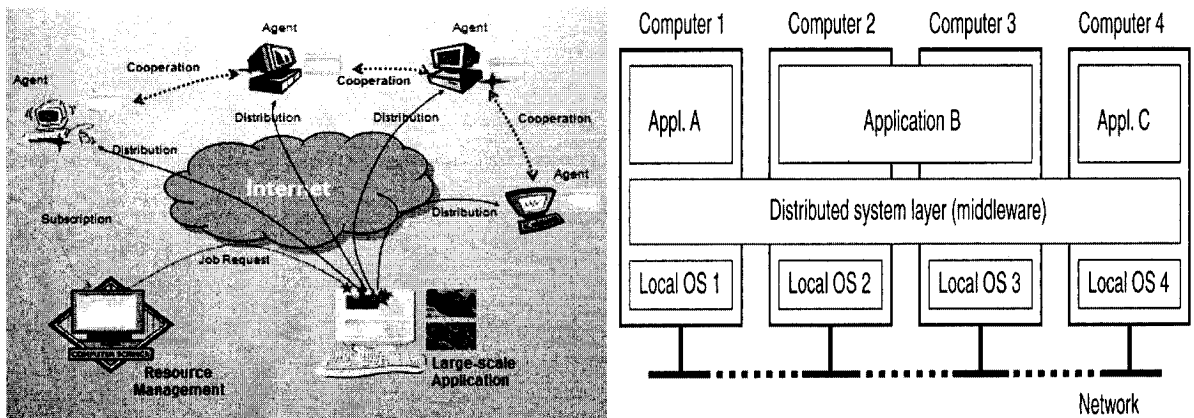
c) When designing distributed systems, one need to consider the issues and challenges that comes with distributed systems implementation. These include **Heterogeneity, Openness, Transparency** and **Scalability. Give** a description for each one of these in relation to distributed systems [4]

d) With the aid of a diagram give a brief description for each of the following [8]
   i.   Centralized systems   iii. Cluster Computing
   ii. Grid Computing   iv.   Cloud Computing

Question II

a. With the aid of a diagram give a brief description for each of the following [3]
   i.   Virtual Machine Monitor (VMM)
   ii. Host Operating System
   iii. Guest Operating System

b. **Give** any **four examples** of Server based virtualisation software. What are the advantages of using virtualisation when implementing servers? [4]

c. In computing, virtualization is a broad term that refers to the abstraction of computer resources. For example, platform virtualization is one form of virtualisation which separates an operating system from the underlying platform resources as shown in the diagram below.

'Non-virtualized' system
A single OS controls all hardware
platform resources

Virtualized system
It makes it possible to run multiple Virtual
Containers on a single physical platform

X86 Multi-Core, Multi Processor
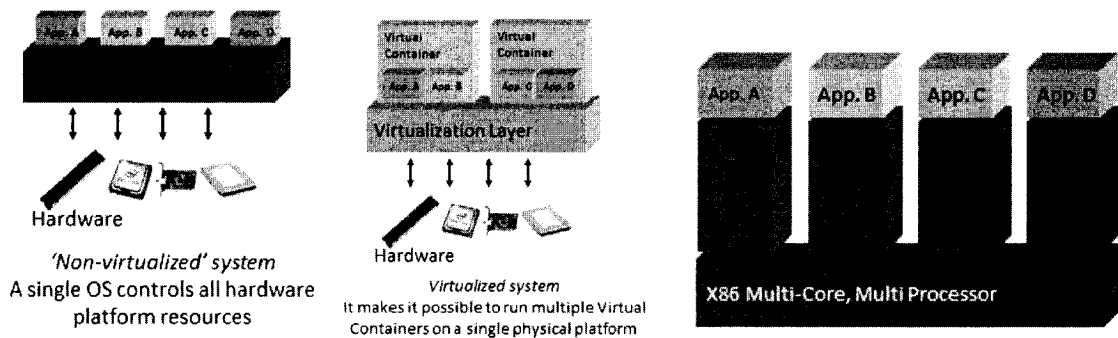
   i. Give a brief description of any four examples of Desktop Virtualization Software [2]

   ii. Choose any one of the desktop virtualisation software you are very familiar with and briefly discuss the following [11]
       1. Hardware and system requirements
       2. Supported operating systems
       3. Overview of installation procedure
       4. Creation and managing the virtual machine
       5. Limitation of the virtual machine

SECTION B

This section has four Questions. Choose any three questions

Question I

a) The logical organization of distributed systems into software components is referred to as software architecture. With the aid of a diagram, name and give a brief description of the **any three most common software architecture styles** in distributed systems [6]

b) The concept of distributed computing is the most efficient way to achieve the optimization. Distributed computing is currently implemented anywhere including intranet, Internet or mobile ubiquitous computing. It deals with hardware and software systems that contain more than a single processing, storage and run in concurrently. Give and discuss **three disadvantages** of implementing distributed systems [3]

c) With the aid of the diagram, Give a brief description for each of the following distributed system architectures [4]
    i. Client-server
    ii. 3-tier architecture
    iii. Peer-to-peer
    iv. Space based

d) Describe each of the following in relation to name services in distributed systems [4]
    i. Name space
    ii. Bindings
    iii. Resolution
    iv. Name server

e) Redundancy is a common way to mask faults. Name and discuss the three major ways of masking faults [3]

Question II

a) Threads implementation can be achieved at the Kernel-level or User-level. With the aid of the diagram, briefly discuss the two implementations giving the advantages and disadvantages of each implementation over the other [4]

b) Threads gain much of their power by sharing an address space in memory. However, this is not the case for Distributed Systems. There is no memory address sharing in distributed systems. However, multithreading can be used to improve the performance of individual nodes in a distributed system. Give a detailed description of multithreading implementation in distributed system give the advantage and disadvantage of each of the following [4]
   i.   Multithreaded Clients
   ii. Multithreaded Servers

c) There have been a number of bigger projects based on distributed systems currently under way and in use today. One such example is the **Collaborative Knowledge Bases – Wikipedia. Give** any other two examples and then describe the three projects in detail [5].

d) The table below shows the seven different forms of transparency in a distributed system. Give a brief description for each one of them [7]

Transparency
Access
Location
Migration
Relocation
Replication
Concurrency
Failure

Question III

a) Compare and contrast between the following communications types [4]
   i. **Persistent** versus **Transient** Communication
   ii. **Asynchronous** versus **Synchronous** Communication

b) The diagram below shows the **Remote Procedure Call** (RPC) Method used in distributed systems. Draw the diagram and give a brief description of the RPC method. Explain how the system add two numbers i and j [5]
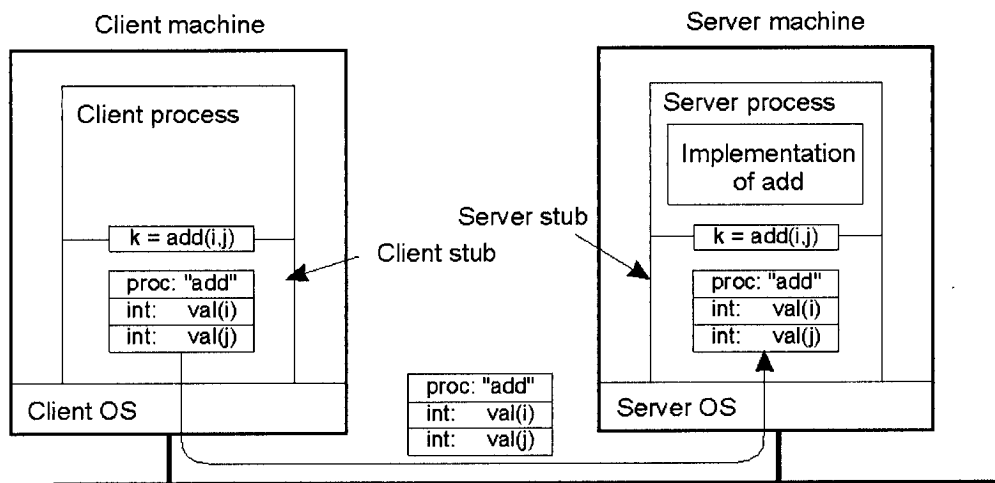
c) In distributed Systems, the two main reasons for data replication are Reliability and performance. Give the advantages of data replication and how this leads to reliability and better performance [5]

d) Names in Distributed Systems are usually organized into Name Spaces usually represented as labeled and directed graph. With the aid of the diagram discuss this implementation by citing the following terms in your discussion [4]
   i. Leaf node
   ii. Directory node
   iii. Root Node
   iv. Path Name

e) Gives a brief description of each of the following in relation to naming entities in distributed systems [2]
   a. Name
   b. Access Point
   c. Address
   d. Identifier

QUESTION IV

a) For large scale Distributed Systems, name spaces are usually organized hierarchically. In this case, name spaces are partitioned into three logical layers. These are Global Layer, Administration Layer and Managerial Layer. Using the Internet Domain System as an example, explain how this can be achieved [3]

b) What is a consistency model? Give a brief description of each of the following consistent models [5]
   i.   Strict consistency
   ii. Causal Consistency

c) Fault tolerance is the ability of a system to continue to provide service in the presence of faults. A system in this definition refers to a collection of components which include machines, storage devices, networks, etc. Describe each of the following in relation to fault tolerance [3]

   i.   Fault
   ii.   Error
   iii. Failure

d) Distributed systems should be constructed so that they can seamlessly recover from partial failures without a serious effect on the system performance. Dependable systems are fault tolerant. Name and discuss the major characteristics of dependable systems. [4]

e) Failures affect the ability of the system to provide the service it advertises. In a distributed system, service interruptions may be caused by the faulty performance of a server or a communication channel or both. Dependencies in distributed systems mean that a failure in one part of the system may propagate to other parts of the system. Name and describe the major types of failures in distributed systems [5]

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2010 ACADEMIC YEAR FIRST SEMESTER FINAL EXAMINATIONS

GEO 111: INTRODUCTION TO HUMAN GEOGRAPHY I

TIME: THREE HOURS

INSTRUCTIONS: QUESTION 1(40%) AND ANY OTHER 3 (20% EACH)

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1. Using Table 1 showing employment data in two sectors in Zambia:

a) Calculate the location quotient for each province and each sector.

b) Explain the reason for the highest and lowest quotient for each sector.

Table 1: Number of people employed in Education and Community Services in Zambia-2004

	Region	Total National Employment	Education	Health
1	Central	50,399	4,626	7,877
2	Copperbelt	160,609	9,542	15,597
3	Eastern	45,089	4,388	8,818
4	Luapula	71,960	3,321	4,761
5	Lusaka	193,591	6,839	27,704
6	North Western	76,400	2,837	2,522
7	Northern	19,585	5,162	5,712
8	Southern	64,013	6,142	12,143
9	Western	35,571	3,073	5,638
	Total	**727,149**	**45,930**	**48,034**

Source: Hypothetical

2. Discuss the statement that, 'it is advantageous to use the regional and systematic approaches in studying geography'.

3. Christaller's Central Place Theory is too hypothetical to be of any relevance to the Zambian situation'. Discuss.

4. With the aid of illustrations, indicate how labour costs and economies of agglomeration affect the location of an industry.

5. Write short explanatory notes on **ALL** of the following:
   a) Historical urban communities
   b) Modern ideas of evolution
   c) Push and Pull factors **IN** migration
   d) The nearest neighbour index
   e) Multiple-nuclei land use model

6. Discuss the applicability of Hagerstrand's diffusion model with reference to Zambia.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 1310: INTRODUCTION TO GEOGRAPHY

TIME: **THREE (3) HOURS**

INSTRUCTIONS: Answer **Question 1** and any other three questions. All questions carry equal marks. Candidates are encouraged to use illustrations wherever appropriate. Use of an approved calculator is allowed.

1. Study Table 1 and then answer the questions that follow:

Table 1: Largest cities in the USA

City	Population
New York	8,175,133
Chicago	7,695,598
Dallas	697,816
Houston	6,399,451
Los Angeles	7,792,621
Philadelphia	3,526,006
Phoenix	1,445,632
San Antonio	827,407
San Diego	707,402
San Jose	350,942

Source: CIA (2001) The World Factbook

(a) Rank the cities according to their population sizes.

(b) Calculate the deviation of the actual from the expected population.

(c) Construct the rank-size graph.

(d) Comment on the shape of the graph.

2. Explain the three basic population pyramids that a country displays as it transits from an undeveloped state to a highly developed state.

3. Discuss any five factors that affect industrial location.

4. Describe the three types of igneous rock according to the chemistry of the rock, the temperature of the magma and the depth at which cooling has taken place

5. Describe any five diastrophic processes and the features they produce.

6. Describe the internal structure of the earth, making reference to rock density, mineralogy, temperature, state of rocks, and the volume of layers.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

INSTITUTE OF DISTANCE EDUCATION

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 1310: INTRODUCTION TO GEOGRAPHY

TIME: THREE (3) HOURS

INSTRUCTIONS: Answer **Question 1** and any other three questions. All questions carry equal marks. Examples and illustrations will be credited. Use of a certified calculator is allowed.

1. Study Table 1 below and then answer the questions that follow:

Table 1: Largest cities in the USA

United States of America	
City	**Population**
New York	8,175,133
Chicago	7,695,598
Dallas	697,816
Houston	6,399,451
Los Angeles	7,792,621
Philadelphia	3,526,006
Phoenix	1,445,632
San Antonio	827,407
San Diego	707,402
San Jose	350,942

Source: CIA (2001) The World Factbook

   (a) Rank the cities according to their population sizes.

   (b) Calculate the deviation of the actual from the expected population.

   (c) Construct the rank-size graph.

   (d) Comment on the shape of the graph.

2. Explain the biotic factors that affect the spatial distribution of organisms on the surface of the Earth.

3. Discuss the components of the formula $f'(Cl, O, R, P, T)$ representing the five soil forming factors.

4. With clear examples, explain anthropologist Leslie White's ideological, technological, and sociological components of culture.

5. Discuss the challenges faced by rural-urban migrants in Zambian urban areas.

6. Explain the components of the population equation $N_1 = N_0 + B - D + I - E$ and show how each component contributes either to population growth or population decline.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 2130: THE GEOGRAPHY OF AFRICA WITH SPECIAL REFERENCE TO
ZAMBIA

TIME: THREE HOURS

INSTRUCTIONS: Answer any four questions. All questions carry equal

marks. Candidates are advised to make use of

illustrations wherever appropriate.

---

1.   'Zambia's climate is characterised by three seasonal rhythms'. Explain.

2.   Describe the natural vegetation found in the Equatorial and Savanna regions.

3.   'Africa is well endowed with natural resources that can be a basis for
industrialization, prosperity and poverty reduction'. Discuss.

4.   Explain the assertion by Pritchard (1979) that' Africa appears to be the home of Early
Man.'

5.   Describe the location of productive activities in Ghana and discuss their implications
for national development.

6.   Either (a) Explain the roles played by land reform, agriculture, and tourism in
economic development of Kenya.

OR   (b) Explain the development strategies that Zambia followed before 1991, and
compare them to those followed after that date.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR FINAL EXAMINATIONS
GES 2422: STATISTICAL METHODS IN GEOGRAPHY

TIME: **Three hours**

INSTRUCTIONS: **Answer any FOUR questions**
                    All questions carry equal marks
                    Use of an approved calculator is allowed

1. Write short explanatory notes on **ALL** of the following:

    a) Importance of statistics
    b) Levels of measuring geographical data
    c) Measures of dispersion
    d) Parametric and non-parametric statistical tests
    e) Inferential statistics.

2. Professor Mwenzi conducted a study on 'GES 2422 students' awareness of the degradation of the environment and their perceived capacity to take action to improve the environment'. Quantitative data was collected using a questionnaire while qualitative data was collected through interviews and observation. A week later, Dr. Nchimunya conducted the same research whose sample was collected from the same population as Professor Mwenzi's using the same methods. Surprisingly the results of the two researchers were significantly different.
    Explain what could have led to the differences in the research findings of the two researchers.

3. People who get angry easily tend to be more likely to have heart disease. That is the conclusion of a hypothetical study that followed a random sample of 12,986 people from three locations in Zambia over a period of four years. All subjects were free of heart disease at the beginning of the study. The subjects took the *Spielberger Trait Anger Scale*, which measures how prone a person is to sudden anger. The 8,474 people in the sample who had normal blood pressure were classified according to whether they had "coronary heart disease" (CHD) or not and whether they had low anger, moderate anger, or high anger according to the Anger Scale. The classification summary is given in Table 1. What conclusion can you make about the findings of this study at $\alpha = 0.05$?

Table 1: Respondents with and without coronary heart disease (CHD)

Condition	Low Anger	Moderate Anger	High Anger
CHD	53	110	27
No CHD	3057	4621	606

Source: Hypothetical

4. One goal of national parks is to provide recreational opportunities for the public to visit and experience natural and cultural areas of national significance. You decide to conduct a study on the importance of the Mosi-oa -Tunya National Park in the Southern Province of Zambia:

   a) Formulate a statement of the problem
   b) Formulate the aim and three (3) objectives of the study
   c) Construct a questionnaire for collecting the required data

5. Suppose that a student carried out a study to assess whether there is an association between tree height and weight. She measured the heights and weights of ten trees in a forest in the Northern Province of Zambia and recorded her results as shown in Table 2. What conclusion did the student make assuming that the sample was random and normally distributed at $\alpha = 0.01$?

Table 2: Tree height and weight

Tree No.	1	2	3	4	5	6	7	8	9	10
Height (mts)	74	63	69	62	65	60	65	70	68	72
Weight (kgs)	210	130	175	120	150	102	120	170	145	185

Source: Hypothetical

6. A fire insurance company wants to relate the amount of fire damage in major residential areas to the distance between the residence and the nearest fire station. A sample of fifteen recent fires in this city is selected. The extent of damage (Y), and the distance (X) between the fire and the nearest fire station are recorded as shown in Table 3.

   a) Plot the data provided in Table 3
   b) Develop a regression equation so as to come up with a regression analysis related to data provided in Table 3.

c) Draw a line of best fit in your scatter diagram.
d) Define your regression equation.
e) How much fire damage (in thousand Kwacha) would be expected if the distance is 9.0 km?

Table 3: Relationship between fire damage and distance from the fire station

Distance from the fire station (Km)	Fire damage (in thousand K)
3.4	26.2
1.8	17.8
4.6	31.3
2.3	23.1
3.1	27.5
5.5	36.0
0.7	14.1
3.0	22.3
2.6	19.6
4.3	31.3
2.1	24.0
1.1	17.3
6.1	43.2
4.7	36.4
3.8	26.1

Source: Hypothetical

END OF EXAMINATION

3

THE UNIVERSITY OF ZAMBIA

INSTITUTE OF DISTANCE EDUCATION

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES: 2422 STATISTICAL METHODS IN GEOGRAPHY

TIME: THREE (3) HOURS

INSTRUCTIONS: ANSWER QUESTION ONE (1) AND ANY OTHER THREE. USE OF RELEVANT EXAMPLES AND ILLUSTRATIONS IS ENCOURAGED

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1. Ecologists have long advocated recycling newspapers as a way of saving trees and reduce landfills. An ecologist used a scaling technique to ascertain how familiar the residents of Chipata were with the recycling centers A and B. Assuming the respondents were randomly selected and that the scaling was done on an interval scale and that no prior expectations about the direction of the difference between the mean familiarity scores for the two sectors, what conclusion would this Ecologist have made based on the data presented in Table 1. Use the 95% accuracy level.

Table 1: Observation for recycling familiarity study

Recycling Centre A	Recycling Centre B
7.4	13.4
10.2	10.7
8.1	9.3
6.5	11.4
7.4	10.7
8.1	8.7
1.3	6.3
5.8	11.8
5.1	8.8
6.7	10.1
4.8	9.9
7.8	8.4
11.2	4.9
9.5	8.8

2. An experiment aimed at determining the relative effectiveness of animal feed with regards to the gain of weight of pigs is conducted. The results are given in Table 2.

Table 2: Weight of pigs and feed in Kg

Weight of pigs (y)	147	125	160	118	149	128	150	145	115	140	152	155
Feed (Kg) (x)	56	42	72	36	63	47	55	49	38	42	68	60

Source: *Hypothetical*

(a) Plot the data that are presented in Table 2
(b) Conduct a regression analysis so as to come up with a regression equation related to data provided in Table 2.
(c) Draw a line of best fit in your scatter diagram.
(d) Define your regression equation.
(e) What could be the weight of the pig which has been given feed weighing 80kg?

3. As a way of mitigating the effects of drought, the Disaster Management and Mitigation Unit under the office of the Vice President embarked on a food relief distribution programme in Chief Mumena. A number of villages were identified and 90kgs bags of maize were distributed. Table 3 shows the number of bags which were distributed in each village. Use the 0.05 significance level to prove whether there was a significant biasness in the manner bags of maize were distributed in the identified villages.

Table 3: Number of 90kg bags of maize distributed during the drought mitigation programme

Mapped villages	Number of maize bags
A	48
B	20
C	72
D	84
E	120
F	36
G	32
H	68

Source: *Hypothetical*

4. Provide reasons for conducting a thorough literature review as part of a research process.

5. Solid waste disposal is one of the most disturbing environmental issues faced by land-use planners in growing urban centres. You decide to conduct a study on the problems of solid waste management in Kalingalinga compound in Lusaka,

   (a) Formulate a relevant statement of the problem
   (b) Formulate a relevant aim and three (3) objectives of the study
   (c) Construct a questionnaire for collecting such data.

6. Explain different components of a research proposal.

END OF DEFERRED EXAMINATIONS

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 3262: BIOGEOGRAPHY

TIME: Three Hours

INSTRUCTIONS: Answer any four questions. The use of a Philip's University Atlas is Allowed and candidates are encouraged to make use of illustrations wherever appropriate.

---

1. Write short explanatory notes on **all** of the following:

   a) The importance and relevance of biogeography to humans

   b) Historical Biogeography

   c) Vegetation zonation

   d) Physiological adaptation

   e) The scientific name of an organism.

2. What do you understand by the term *process* and what is its importance in biogeography at the local level?

3. Cox and Moore (1984) state that 'niche refers to the status or profession occupied by an organism in a community whereas habitat is the address'. Elucidate.

4. With the aid of an annotated graphical model, explain the population abundance maintained by a species of an organism along a gradient of a physical factor like temperature in its environment.

5. With the help of specific examples, explain the factors that made Darwin come up with his theory of evolution which was apparently in conflict with the belief in existence at that time.

6. Explain why Biogeographers unlike their counterparts in physics and geology have readily accepted the theory of continental drift.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 3330: ENVIRONMENT AND DEVELOPMENT

TIME: Three hours

INSTRUCTIONS: Answer any FOUR questions

                    All questions carry equal marks

---

1. Explain what is causing the thinning of the stratosphere's ozone layer and its environmental effects.

2. From an ecological economic perspective, explain how development can negatively affect the environment.

3. 'The poor are the victims of environmental degradation and are also the agents'. Discuss.

4. 'Sustainable development focuses on improving the quality of life of people without increasing the use of natural resources beyond the capacity of the environment to supply them indefinitely'. Explain.

5. 'Agricultural biotechnology does more harm to the environment than good to society'. Discuss.

6. 'An EIA is in the ambit of development, not outside it'. Evaluate this assertion with respect to the Kangaluwi Copper Mine Project in the Lower Zambezi National Park.

End of Examination

THE UNIVERSITY OF ZAMBIA

INSTITUTE OF DISTANCE EDUCATION

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 3330: ENVIRONMENT AND DEVELOPMENT

TIME: Three hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. Use of appropriate illustrations and examples is encouraged.

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1. Explain the environmental and health problems associated with pollution from lead, ozone and nitrogen oxides.

2. Using examples, explain at least four main characteristics of contemporary environmental problems that make it difficult to resolve them.

3. 'Although economic development and environmental protection are viewed as goals that can be pursued simultaneously, the two have historically been viewed as conflicting'. Discuss.

4. Outline and discuss four preconditions that are critical to the achievement of sustainable development.

5. Explain how global warming is induced and why its effects can be felt differently in different regions.

6. Discuss four underlying drivers of deforestation and suggest ways in which they can be addressed to achieve sustainable forest management.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

INSTITUTE OF DISTANCE EDUCATION

2014/2015 ACADEMIC YEAR DEFERED FINAL EXAMINATIONS

GES 3330: ENVIRONMENT AND DEVELOPMENT

TIME: Three hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. Use of appropriate illustrations is encouraged.

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1. 'Economic development and environmental protection cannot be pursued simultaneously'. Discuss.

2. Outline at least four causes of land degradation in Zambia and explain how they can be prevented.

3. Write Short explanatory notes on ALL of the following:

   a) Habitat and ecological niche
   b) Chronic toxicity
   c) The precautionary principle
   d) Lead pollution
   e) Acid rain

4. With the aid of examples, explain how anthropogenic activities contribute to global warming and suggest ways in which it can be mitigated.

5. List and explain at least four realities that act as obstacles to sustainable development.

6. 'Although a green economy is desirable, achieving it is a mammoth task'. Discuss.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 3342: ENVIRONMENTAL PLANNING AND MANAGEMENT

TIME: Three hours

INSTRUCTIONS: Answer any four questions. All questions carry equal marks. Use of appropriate illustrations is encouraged.

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1. Sichi-enviro group of companies intends to start up a limestone mining project in Ndola district in chief Chiwala's area. The main goal of this group is achieving a green portfolio in all its operations. Therefore, before the project is implemented, Sichi-enviro embarks on carrying out an environmental impact assessment (EIA). Given this scenario:
   a) State and explain what the company needs to do before conducting the EIA.
   b) Describe the main stages of the EIA process.
   c) State the benefits of conducting an EIA.

2. The Government of the Republic of Zambia is concerned about the high concentration of sulphur dioxide pollutants in Zambian cities. A number of industrial units have been identified as sources of these pollutants. The government, in this regard, is considering using standards and selected economic instruments to address the situation. The instruments are targeting production processes, atmospheric emissions from the units and the products distributed by the industrial units. Assuming you are working for the government as an environmental advisor, explain three types of standards and two types of economic instruments you would advise the government to use.

3. Briefly describe an Environmental Management System (EMS) and explain its benefits.

4. (a) Describe two challenges associated with commons management.

   (b) What evidence exists against Hardins's (1968) *Tragedy of the Commons* thesis that resource degradation is inevitable in the commons?

5. 'Genuine decentralization of natural resources management is impossible in Zambia'. Discuss.

6. Outline four principles of sustainable development and explain how they can be used to inform environmental policy.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

INSTITUTE OF DISTANCE EDUCATION

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 3361: POPULATION, CULTURE AND ENVIRONMENT

TIME: Three hours   DEFERRED EXAMINATION

INSTRUCTIONS: Answer any **FOUR** Questions.
All questions carry **equal** marks. Use of an approved calculator is allowed.
Candidates are encouraged to use illustrations wherever appropriate

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1. Outline and explain any five (5) variables that influence fertility.

2. With the help of annotated diagrams, contrast between Sharp pyramid and Middle pyramid of population age structure.

3. Discuss the relevance of Robert Thomas Malthus' 'population debate' to today's world rapid population growth. With reference to Zambia, suggest what should be done to regulate rapid population growth

4. 'Anti – natalism policy is not very effective in most developing countries'. Analyse this assertion.

5. 'Large populations affect social and economic development'. Discuss

6. Write short explanatory notes on each one of the following
   (a) Population Registers
   (b) Vital Statistics Methods
   (c) Distinguish between De jure Census and Defacto Census
   (d) Sample Surveys
   (e) Labour Migration

END OF THE EXAMINATION

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 4372: TOURISM, ENVIRONMENT AND DEVELOPMENT

TIME: THREE (3) hours

INSTRUCTIONS: Answer **Question 1 (40 marks)** and any other 3 Questions (20 marks each)
Candidates should use illustrations wherever relevant
Use of an **approved** calculator is allowed

1. Chipembele Country Club has 25 single rooms and is located on a 20 acre property which hosts a large botanic garden. The garden has a scenic walking trail covering a total of 268 metres. The trail is 1 metre wide on average and each visitor uses 1 square metre. Guides are not required and guests are free to walk round the garden unaccompanied. The garden is open from 06:00 hours to 18:00 hours every day of the year apart from the 11 public holidays. In 2014, the garden received 729, 443 visitors. The club employs 3 grounds men to manage the gardens although the ideal number should be 8 grounds men. You have been asked by the owner to give advice on the ideal number of visitors the garden should have.

    a) i) Using the following correction factors;
        Precipitation = 1.68%, Erosion = 32.28% and Slope = 32.28%

        Calculate the *Physical*, *Real* and *Effective* carrying capacities giving both daily and annual visitor capacities (show all calculations).

        ii) What measures can be used to reduce the number of visitors to the garden?

    b) Calculate the annual occupancy rate if Chipembele Country Club sold a total of 2,917 room nights in a given year?

    c) Calculate the average length of stay (L) for a group of 18 guests to the country club if 10 guests stayed for 5 nights, 5 guests stayed for 3 nights and the remaining guests stayed for 2 nights.

2. Write brief explanatory notes on ALL of the following:
    a) Agglomeration benefits
    b) Tourism leakages
    c) Guest/host interaction
    d) Demonstration effect
    e) Tourism-environment symbiosis.

3. "Tourism carries the seed of its own destruction" (Keyser, 2009:351). Discuss.

4. Evaluate Cohen's typology of tourists outlining the major criticisms.

5. Discuss the socio-cultural impacts of tourism in Zambia.

6. Explain the ten characteristics of tourist products.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

INSTITUTE OF DISTANCE EDUCATION

2014 ACADEMIC YEAR FINAL EXAMINATIONS

GES 4372: TOURISM, ENVIRONMENT AND DEVELOPMENT

TIME: **THREE (3) hours**

INSTRUCTIONS: Answer **Question 1** and any other 3 Questions. All questions carry equal marks.
Candidates should use illustrations wherever relevant.

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1. Write short explanatory notes on **ALL** of the following:
    a) Time-shares and lease back arrangements
    b) Cohen's typology of tourists
    c) Tourism take-off stage
    d) Leisure travellers
    e) Butler's Model of tourism development.

2. Discuss the environmental impacts of tourism.

3. Assess the possible outcomes of the 'demonstration' and 'acculturation' effects of tourism on host communities in Zambia.

4. Discuss the contention that the definition of tourism is problematic.

5. Evaluate the potential of including community based tourism in local planning for tourism in Zambia?

6. Evaluate the benefits of using a SWOT analysis to evaluate a tourist entity.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

INSTITUTE OF DISTANCE EDUCATION

2014 ACADEMIC YEAR DEFERRED EXAMINATIONS

GES 4372: TOURISM, ENVIRONMENT AND DEVELOPMENT

TIME:　　　　　THREE (3) hours

INSTRUCTIONS:　Answer any 4 (four) Questions. All questions carry equal marks.
Candidates should use illustrations wherever relevant

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1. Write short explanatory notes on **ALL** of the following:
   (a) Infrastructure in tourism
   (b) Leisure travellers
   (c) Incomparability of tourism statistics
   (d) Eco-tourism
   (e) Butler's Model of tourism development

2. Discuss the history of travel outlining the four stages of the development of the industry.

3. 'Tourism is bad for culture'. Discuss.

4. Explain the three methods which can be used to ensure environmental sustainability in tourism.

5. Discuss the relevance of Government involvement in planning for tourism at all levels.

6. Outline the forms of state organisations and their principle functions in organising tourism in their countries.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

GES 6431: PLANNING LAW & GOVERNANCE

TIME: Three hours

INSTRUCTIONS: This is an open book Examination. The legal instruments allowed
                        in the Examination are as follows:

                        a) Town and Country Planning Act, Chapter 283 of the
                           Laws of Zambia
                        b) Housing (Statutory and Improvement Areas) Act,
                           Chapter 194 of the Laws of Zambia
                        c) Local Government Act, Chapter 281 of the Laws of
                           Zambia
                        d) Environmental Management Act No.20 of 2011
                        e) Environmental Protection and Pollution Control
                           (Environmental Impact Assessment) Regulations (1997)

                        Question ONE is COMPULSORY and ALL candidates should
                        answer it

                        Candidates should also answer any other TWO questions

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Question 1

Honourable Peterson Chipeshabantu, MP has been appointed as new Minister of Local
Government and Housing. He is renowned for being uncompromising on issues of good
governance. As a planner by profession you understand that land use planning and control is in
modern society conceived as an appendage of good governance; and a central feature of the
regulatory functions of government. You are also aware that it is ordinarily recognised that this
process of planning is a Local Government function.

Prepare a brief for the Minister on his responsibility regarding policy development and guidelines for land use planning and control in accordance with the law. What authority or power do Local Authorities have in this respect and where is this authority derived from? Please cite relevant sections of the appropriate legislation. Advise on any shortfalls of the law relating to land use planning that you may be aware of for the information of the Minister.

QUESTION 2

Mr. Muzenga had a successful visit to Chiefteness Shikabeta's area in Rufunsa district. The village head man was especially helpful and allocated Mr. Muzenga land bordering a perennial stream used by the local population. The stream is also the home of one of Zambia's uncommon monitor lizard that has been spotted only in two places countrywide. Mr. Muzenga wants to start a fish farm to produce over 100 tonnes of fish per year. To achieve this he needs to secure the stream from which he will be drawing water for his fish ponds. Since the stream also has a sandy beach, Mr. Muzenga wants to introduce alien species of flora and fauna. He is not sure what is required of him by law.

You are the District Environmental Protection Officer stationed at Chongwe District. Mr. Muzenga approaches you for advice. Identify the legislation that regulates this kind of development and the organisation or authority that he needs to deal with. Provide Mr. Muzenga with a written explanation of what this legislation requires of him to achieve his objective. Be sure to provide details of any information he may be required to provide relevant authorities.

QUESTION 3

The spirit of the Housing (Statutory and Improvement Areas) Act, Cap 194, was that government has a 'moral duty to the populace of protecting them from the *'caprice and avarice of astute profiteers'*. It had been argued that by permitting prospecting in housing in site and service areas *'we shall be creating a nation of Landlords whose aim will be profiteering and exploiting the unwary masses, because it will virtually be impossible to control the rents'*. Provisions in section

5 and 39 of the Housing (Statutory and Improvement Areas) Act were thus intended to safeguard against this. The new government decides to strictly enforce the spirit of the Act.

The Home Owners Association approaches you for your expert opinion. What argument would you make to either support or contradict the government especially with regard to the provision of section 39 and 42 of the Act? Include any other arguments based on your expert knowledge with regards to land markets.

QUESTION 4

Mr. Banda holds a 99 years lease on farmland off Pemba Highway. Part of Mr. Banda's land contains a substantial amount of lime deposits, which is a major raw material in the production of cement. Mr. Banda registers a company with PACRA called Pemba Quarries Zambia Limited. Pemba Quarries Zambia Limited conducted a scoping exercise of Mr. Banda's land in order to get the views of the persons who may be affected by a quarrying project. He subsequently prepared an Environmental Impact Statement which was submitted to the Zambia Environmental Management Agency (ZEMA). ZEMA approved the project, with conditions. Pemba Quarries Zambia Limited started blasting and mining operations to mine limestone, clay and sand.

The small scale farmers whose farms surrounded Mr. Banda's land do not have title to the land they live on and use as it is held under customary tenure. They went to complain to the Director at the Ministry of Mines over the blasting and mining operations. They alleged that the area is designated as farming and not mining area. They claim that their chickens have stopped laying and cracks have appeared in the walls of poultry houses on their land. They have a cooperative called Small Scale Poultry Farmers for Business Cooperative (SPFBC) and owe NATSAVE huge amounts of money. The Director at the Ministry of Mines says he 'just gives mining licenses and change of use is the responsibility of the planners'.

SPFBC want to sue Mr. Banda and Pemba Quarries Zambia Limited. They are unfamiliar with the statutes that regulate land use. What evidence of possible breach of legal requirements on the

part Mr. Banda and Pemba Quarries Zambia Limited should they look for to build their case? Give them information supported by the law, which can help them make a case against Mr. Banda and Pemba Quarries Zambia Limited.

End of Examination

THE UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

UNIVERSITY DEFERRED EXAMINATIONS

JUNE – JULY 2015

M2100: – ANALYTICAL GEOMETRY AND CALCULUS

INSTRUCTIONS:
1. Answer any **five(5)** questions.
2. All questions carry equal marks.
3. Show all the necessary work to earn full marks.
4. Write down the questions attempted on the front page of the main booklet.
5. Use of calculators and tables is allowed.

TIME ALLOWED: Three **(3)** hours.

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1. [a] Sketch the graph of the conic whose equation is given by
$$4x^2 + 2y^2 - 8x - 4y + 6 = 20$$
Hence, state its vertex (or vertices), focus (or foci) and directrix (or directrices)

[b] Find the standard equation of the hyperbola with vertices at $(3, -5)$ and $(3, 1)$ having asymptotes $y = 2x - 8$ and $y = -2x + 4$.

2. [a] Find ' c' of the mean value theorem if
$$f(x) = x(x-1)(x-2), \quad x \in \left[0, \frac{1}{2}\right].$$

[b] Evaluate:

[i] $\lim\limits_{x \to 0} \dfrac{4^x + 3^x - 2}{4x}$

[ii] $\lim\limits_{x \to 0^+} \left(\dfrac{1}{e^x - 1} - \dfrac{1}{x} \right)$

[c] The polar equation of a conic section is given
$$r = \frac{2}{4 + 3\cos\theta}$$
Sketch the polar equation of above conic.

3 **[a]** Solve the following differential equation:

  [i] $\cos x \dfrac{dy}{dx} + y \sin x = \sec^2 x$

  [ii] $y'' - 10y' + 41y = 0$

[b] [i] If $u = \ln \dfrac{x^2 + y^2}{x + y}$, find the constant k

  such that $x \dfrac{\partial u}{\partial x} + y \dfrac{\partial u}{\partial y} = k$

  [ii] If $z = xy f\left(\dfrac{x}{y}\right)$, show that $x \dfrac{\partial z}{\partial x} + y \dfrac{\partial z}{\partial y} = 2z$

[b] Evaluate the following integral:

  [ii] $\displaystyle \int \dfrac{x^3}{\sqrt[3]{x^2 + 4}}\, dx$

  [iii] $\displaystyle \int \dfrac{1}{x^2 \sqrt{16 - x^2}}\, dx$

4. **[a]** [i] Given (ε, δ), explain what is meant by the statement
  $$\lim_{x \to c} f(x) = L$$
  Hence, show that

  $$\lim_{x \to -2} \dfrac{1}{x + 5} = \dfrac{1}{3}$$

  and state the value of $\delta > 0$ given that $\epsilon = 0.05$

  [ii] Find the volume generated by the function
  $f(x) = \cos x$ in the interval $[-\pi, 0]$

[b] Find $\displaystyle \int \dfrac{5x^2 + 20x + 6}{x^3 + 2x^2 + x}\, dx$

[c] Given $f(x) = \displaystyle \sum_{n = 0}^{\infty} \dfrac{x^n}{n!}$

  [i] Show that $f(x) = f'(x)$
  [ii] Show that $f(0) = 1$
  [iii] Identify the function f

2

5 **[a]** Expand by Taylor's theorem

    [i] $f(x) = \cos x$

    [ii] $f(x) = 2x^3 + 7x^2 + x - 6$ in powers of $(x-2)$.

  [b]   [i]   Find : $\displaystyle\int \frac{2x^3 - 4x^2 - 15x + 15}{x^2 - 2x - 8}\, dx$

       [i]   Evaluate: $\displaystyle\int \frac{x}{\sqrt[3]{a + bx}}\, dx$

6 **[a]**   [i]   Find the symmetric equation of a straight line l which passes through the point intersection of the planes Π_1 and Π_2, where

         $\Pi_1 : 3x + 2y + z = 3;$ $\Pi_2 : 2x + y + z = 4$.

    [ii]   Find an equation of the plane through $P(2,3,2)$ that is perpendicular to the plane $\Pi : 3x + y - 6z + 8 = 0$

  [b]   If $u = \ln\dfrac{x^2 + y^2}{x + y}$,

      find the integer value of k given that $x\dfrac{\partial u}{\partial x} + y\dfrac{\partial u}{\partial y} = k$

END OF THE EXAMINATION

UNIVERSITY OF ZAMBIA

SCHOOL OF NATURAL SCIENCES

DEPARTMENT OF MATHEMATICS AND STATISTICS

SESSIONAL EXAMINATIONS-2014/2015

MAT1110- Foundation Mathematics and Statistics for Social Sciences

Instructions:

1. There are two sections in this paper.

2. Answer 5 questions in total with AT LEAST ONE question from <u>SECTION TWO</u>.

4. Show all your work to earn full marks.

Time Allowed: Three (3) Hours

SECTION ONE

1. (a) Find the value of the following:

   (i) $\dfrac{(\sqrt{2}-1)^2}{6-4\sqrt{2}}$

   (ii) $\left(\dfrac{27}{64}\right)^{-\frac{1}{3}}$

   (iii) $\log_{10} 5 + \log_{10} 10 + \log_{10}(\tfrac{1}{5})$

   (b) Find the value of the following:

   (i) $\sin(\tfrac{2\pi}{3})$

   (ii) $\dfrac{1}{\tan(\tfrac{3\pi}{4})}$

(iii) $\sin^2(x) + \cos^2(x)$

(c) (i) Express the rational function

$$R(x) = \frac{2x - 1}{(x - 1)^2(x + 2)}$$

as a sum of partial fractions.

(ii) Evaluate $\displaystyle\int \frac{2x - 1}{(x - 1)^2(x + 1)} dx$

2. (a) (i) Find the equation of the tangent line to the curve $y = \sin 2x$ at $x = \frac{\pi}{4}$

(ii) The total revenue on q units sold is given by $R(q) = 400q - 2q^2$, find q which maximizes $R(q)$.

(b) (i) Find values of a and b given that $2 + 3i - a = \dfrac{2}{1 - i} + ib$

(ii) Solve the equation $4^{x+1} - 2^{2x} = 3$

(c) Let A and B be subsets of a universal set E. Using set operations express the following sets as a single set.

(i) $(A^c \cup B)^c \cap B$

(ii) $(A \cap B)^c \cup (A \cap B)$

(iii) Let A and B be intervals of the real line. Given that $A = [0, 2), B = (-3, 1]$, find the intervals $(A \cup B)^c$ and $A^c \cap B^c$.

3. (a) (i) Given the polynomial $P(x) = x^4 - x^3 + x^2 - 3x - 6$, show that $x + 1$ and $x - 2$ are factors of $P(x)$

(ii) Apply synthetic division to find polynomial $Q(x)$ such that $P(x) = (x + 1)Q(x)$

(iii) Find intervals of real line on which the inequality $(x + 1)(x - 2)(x^2 + 3) \geq 0$ holds.

(b) (i) Find the value of $\dfrac{^8C_6}{^8C_2}$

(ii) Expand $(2x - \frac{3}{x^2})^4$ by binomial theorem and present your answer in the most simplified form.

(c) Prove the following identities:

(i) $\dfrac{\sin^3 x + \sin x \cos^2 x}{\cos x} = \tan x$

(ii) $\dfrac{\cos^2 x}{1 + \sin x} = 1 - \sin x$

(iii) $(1 + \sin x)^2 - (1 + \sin^2 x) = 2\sin x$

4. (a) Given $f(x) = x^3 - 1$,

(i) Determine the intervals in which $f(x)$ increases.

(ii) Determine the intervals in which $f(x)$ is concave up.

(iii) Find the point/points of inflection of $f(x)$ if there are any.

(iv) Sketch the graph of $f(x)$.

(v) Find the area of the region bounded by $y = f(x), y = 0, x = 1$ and $x = 2$

(vi) State with reasoning if $f(x)$ is one - one function.

(vii) Find $f^{-1}(x)$, if it exists.

(b) Find the derivative of the following functions at $x = 0$

(i) $y = \dfrac{\sin x}{1 + \cos x}$

(ii) $y = \left(1 + tan\dfrac{x}{2}\right)^3$

(c) (i) Sketch the graphs of $y = e^x, y = \ln x$ and $y = x$ on the same Cartesian axes.

(ii) Find the value of $\ln e$

5. (a) Given the function $f(x) = \begin{cases} 1 - x & ; x \le 1 \\ x^2 & ; x > 1 \end{cases}$

(i) Sketch the graph of $f(x)$.

(ii) Determine if $f(x)$ is continuous at $x = 1$

(b) Evaluate the following integrals

(i) $\int x^2(1 + x^3)^4 dx$

(ii) $\int \dfrac{\ln x}{x} dx$

(iii) $\int_0^{\frac{\pi}{4}} \dfrac{1}{x^2 + 1} dx$

(c) (i) Suppose you have 102 m of fencing to make two side by side rectangular enclosures as shown below. Find the maximum area that you can enclose.
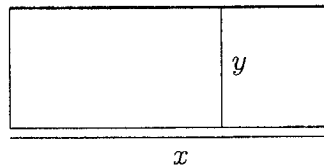
(ii) Find $\dfrac{dy}{dx}$ at $(\pi, 1)$ given that $\cos x + y^2 = 0$

SECTION TWO

6. (a) The grade point averages of 20 UNZA graduate students selected at random from the class of 2014 are as follows:

$$3.2 \quad 1.9 \quad 2.7 \quad 2.4$$
$$2.8 \quad 2.9 \quad 3.8 \quad 3.0$$
$$2.5 \quad 3.3 \quad 1.8 \quad 2.5$$
$$3.2 \quad 2.8 \quad 2.0 \quad 3.2$$
$$2.3 \quad 2.1 \quad 2.5 \quad 1.9$$

(i) Prepare a grouped frequency distribution table with the the first class interval as $1.5 - < 2$

(ii) Draw the corresponding histogram.

(iii) Find the percentage of students in this sample who got a grade point average of less than 2.5

(iv) Give an estimate of mean, mode and median.

(v) State if the given data distribution is approximately symmetrical.

(b) (i) Given mean as 2.7 and standard deviation as 0.5 for the data of part (a), find an interval which includes about 95 percent of the values in the sample.

(ii) Find the median for the following data: 3, 8, 7, 5, 5, 5 , 3, 9, 2, 3.

(c) A Pharmaceutical store delivers an average of 40 prescription-filled orders a day, with a standard deviation of 8 orders. Assuming a bell shaped population for the daily number of prescriptions delivered, find the number of days in a year when deliveries made per day are between 24 and 56. You may not simplify the answer.

7. (a) If A and B are mutually exclusive events and $P(A) = 0.3, P(B) = 0.5$, find

   (i) $P(A \cup B)$

   (ii) $P(A')$

   (iii) $P(A' \cap B)$

   (b) From past experiences, Lusaka Stock Exchange(LUSE) believes that under present economic conditions, a customer will invest in tax-free bonds with a probability of 0.6, will invest in mutual funds with a probability of 0.3 and will invest in both tax-free bonds and mutual funds with a probability of 0.05. Find the probability that under present economic conditions a customer will invest

   (i) in either tax-free bonds or mutual funds.

   (ii) in neither tax-free bonds nor mutual funds.

   (c) A random sample of 200 adults is classified below according to gender and the level of education attained.

	male	female
primary	38	45
secondary	28	50
College	22	17

   If a person is picked at random from this group, find the probability that

   (i) the person is a male.

   (ii) the person is male and has secondary education.

   (iii) the person has secondary education given that he is male.

The University of Zambia
School of Natural Sciences
Department of Mathematics & Statistics
2014/15 ACADEMIC YEAR FINAL EXAMINATIONS
MAT1100 – FOUNDATION MATHEMATICS
22nd June, 2015

INSTRUCTIONS: (1) Write down your **Computer number** and the **TG number** on each answer booklet used.

(2) There are seven questions in this paper. **Answer any Five (5)** only.

(3) Show all essential working to avoid loss of marks.

(4) Write down the **question number** of each question attempted in the first column on the cover of the main answer booklet.

(5) Calculators and tables are **not allowed** in this exam.

TIME ALLOWED: Three (3) hours.

Q1.   (a) The sets A, B, C all intersect and U is the universal set. Shade the part described by the set $(B \cup C) - (A \cap B)$ in a Venn diagram.

(b) (i) Express $f(x) = \dfrac{4-x}{(1-x)(2-x)}$ into partial fractions.

Hence,

(ii) find $\int f(x)dx$.

(c) Given that $A = \begin{pmatrix} 1 & -2 & -1 \\ 0 & 3 & 1 \\ 2 & 0 & -4 \end{pmatrix}$,

(i) find A^{-1}.

Hence,

(ii) solve the system of equations

$$x - 2y - z = 1$$
$$3y + z = 0$$
$$2x \qquad - 4z = -8.$$

(d) Prove that the roots of the equation

$$x^2 + (k+2)x + 2k = 0$$

are real for all real values k.

1

Q2.   (a) (i) Solve the equation

$$|2x - 3| = |x + 3|.$$

(ii) Find the coefficient of x^{11} in the binomial expansion of $(2 - x)^{15}$.

(iii) Express the number $0.12\bar{3}$ in the form $\dfrac{p}{q}$, where $p, q \in \mathbb{Z}$.

(b) Differentiate the function $f(x) = \sqrt{3x + 1}$ from first principles.

(c) Given that $y = 3 + 3x^2 - x^3$, find the equation of the tangent and of the normal at the point where $x = 4$.

(d) Find the length of the straight line from the centre A of the circle

$$x^2 + y^2 + 4x - 6y - 36 = 0,$$

to point $B(6,9)$.

Q3.   (a) Find the solution set of the following inequality

$$\frac{x-2}{2x-3} \geq x.$$

(b) Evaluate the limits:

(i) $\lim_{x \to 2} \dfrac{x^3 - 8}{x^2 - 4}$

(ii) $\lim_{x \to \infty} \dfrac{2x^3 + 1}{2 + x - 3x^3}$

(c) (i) Solve for x in the equation

$$2^{2x+1} = 3(2^x) - 1.$$

(ii) If $xy = 64$ and $\log_x y + \log_y x = \dfrac{5}{2}$, find x and y.

(d) The diagram below shows the shaded region R which is bounded by the curves with equations $y = x^2$ and $y = 8 - x^2$. Find the area of R.

2
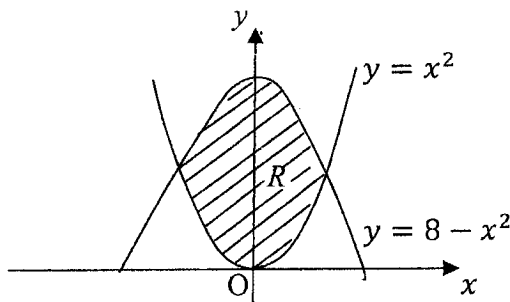
Q4.　(a) Given the sets $A = (-3,2], B = [0,7], C = [-5,1)$ and universal set
　　　$U = (-10,10)$, find each of the following sets and represent them on a number
　　　line:

　　　(i)　$A \cap B'$

　　　(ii)　$A - (B - C)'$

　　(b) Given that $f(x) = (x + 2)(x - 6)$, sketch the graph of $y = \frac{1}{f(x)}$,
　　　indicating the turning points and asymptotes, if any.

　　(c) Express $\frac{2-3\sqrt{5}}{1+2\sqrt{5}}$ in the form $a + b\sqrt{c}$ where, a, b and c are rational numbers.

　　(d) Evaluate each of the following integrals:

　　　(i) $\int \frac{x+2}{x^2(x-1)} dx$

　　　(ii) $\int_0^\pi x\sin x \, dx$

Q5.　(a) For each of the following, find $\frac{dy}{dx}$:

　　　(i) $y = e^{2x}\ln(2x^2 - 1)$

　　　(ii) $\cosh y - 4\sinh^3(x) = 7$.

　　(b) Evaluate the integral
$$\int x(x^2 - 4)^{\frac{1}{3}} \, dx.$$

　　(c) (i) Factorize $f(x) = x^3 - 3x^2 - 10x + 24$ completely.

　　　(ii) Express $z = \frac{4+2i}{(1-2i)^2}$ in the form $a + ib$ where $a, b \in \mathbb{R}$.

　　(d) Find the period and phase shift for the function
$$f(x) = -1 + 3\cos(2x + \pi),$$

　　and hence or otherwise, sketch the curve for $-\pi < x \leq \pi$.

Q6. (a) Use the principle of mathematical induction to prove that for $n \in \mathbb{Z}^+$

$$1^3 + 2^3 + 3^3 + \cdots + n^3 = \frac{1}{4}n^2(n+1)^2.$$

(b) Determine whether the function $f(x) = cosx - secx$ is even or odd or neither.

(c) (i) A solid circular cylinder has fixed volume of $1000\,cm^3$. Show that the total surface area $A\ cm^2$ of the cylinder is related to the base radius $x\ cm$ of the cylinder by the equation

$$A = 2\pi x^2 + \frac{2000}{x}.$$

(ii) Given that x varies, show that A has a minimum when $x^3 = \frac{500}{\pi}$.

(d) (i) Show that

$$\cos(A - B) - \cos(A + B) = 2sinAsinB.$$

(ii) Hence show that

$$\cos 2x - \cos 4x = 2sin3xsinx.$$

(ii) Find all solutions in the range $0 \le x \le \pi$ of the equation

$$\cos 2x - \cos 4x = sinx,$$

giving all your solutions in multiples of π.

Q7. (a) The function f is defined by

$$f(x) = 3x^3 + 6x^2 - 5x - 4.$$

(i) Find the intervals in which the function is decreasing and in which it is increasing.

(ii) Find the maximum and minimum turning points.

(b) Find the exact value of x for which

$$\cos\left(\arcsin\left(\frac{\sqrt{3}}{2}\right)\right) = x + \sqrt{2}.$$

(c) A function f is defined by

$$f(x) = \frac{x-1}{x}, \quad x \in \mathbb{R}, x \ne 0, x \ne 1.$$

Find (i) $(fof)(x)$

(ii) $(fofof)(x)$

(iii) $f^{-1}(x)$

(d) Use Cramer's rule to solve the system of equations:

$$\begin{aligned} x + 2y + 3z &= -2 \\ -2x \quad\quad + z &= 3 \\ x - 3y \quad\quad &= 5. \end{aligned}$$

END OF EXAMINATION

UNIVERSITY OF ZAMBIA

DEPARTMENT OF MATHEMATICS AND STATISTICS

INSTITUTE OF DISTANCE EDUCATION

MAT1100 - FOUNDATION MATHEMATICS

END OF YEAR DEFERRED EXAMINATIONS

2014/2015 ACADEMIC YEAR

TIME ALLOWED: 3 HOURS   DATE: 31 JULY, 2015

INSTRUCTIONS

1. There are **Seven(7)** questions in this paper.
   Attempt any **Five(5)** questions.

2. Write only your **computer number** on each answer booklet you have used.

3. Calculators and use of Tables are not allowed in this paper.

1. **(a)** **(i)** Express the complex number $\frac{2-5i}{3-i}$ in the form $a + ib$ where a and b are rational numbers.

   (ii) Given that $U = \mathbf{R}$ is the universal set, $A = [-\infty, -2)$ and $B = (-12, 15)$, find the set $(A - B) \cup (B - A)$.

   (iii) Find the term independent of x in the expansion $\left(x^2 - \frac{1}{x}\right)^{18}$.

   (b) **(i)** Given that α and β are the roots of the equation $2x^2 - 3x - 7 = 0$, find an equation whose roots are α^2 and β^2.

   (ii) Sketch the graph of the quadratic function $f(x) = 2x^2 - 3x + 5$.

   (iii) Let $f(x) = \frac{2x-1}{x+1}$ and $g(x) = \frac{x+1}{2}$ be functions. Find $(f \circ g)^{-1}(x)$

2. **(a)** **(i)** Express $0.2\overline{53}$ in the form $\frac{a}{b}$ where a and b are integers.

   (ii) The second term in the expansion $(1 - x)(1 + 3x)^n$ is $20x$.
   Find the value of n.

   (iii) Given that A and B are sets, express $[A \cap (A' \cap B)']'$ in its simplest form.

   (b) **(i)** Find the center and the radius of the circle $2x^2 + 2y^2 - 4x + 6y + 1 = 0$.

   (ii) Find the equation of the tangent to the circle $x^2 + y^2 - 4x + 6y + 11 = 0$ at the point $(1, -2)$.

   (iii) Given that $\sin A = \frac{4}{5}$ and $\cos B = \frac{12}{13}$ where A is an obtuse angle and B is an acute angle, find $\tan(A + B)$

3. **(a)** **(i)** Solve the inequality $\frac{2x}{x+3} \leq \frac{1}{2}$.

   (ii) Express $\frac{2}{5+2\sqrt{3}}$ in the form $a + b\sqrt{3}$ where a and b are real numbers.

   (iii) Use Cramer's rule to solve the system of equations:
   $x + y + z = 7$
   $x - y + 2z = 9$
   $2x + y - z = 1$

   (b) Given that the polynomial $f(x) = 2x^3 + 3x^2 + ax + b$ leaves a remainder of -15 when it is divided by $2x - 1$ and that $2x + 3$ is one of its factors,

   (i) find the values of a and b.

   (ii) use synthetic division to find the remainder and the quotient when $f(x)$ is divided by $x + 1$.

   (iii) solve the equation $f(x) = 0$.

4. **(a)** **(i)** Let $\mathbf{A} = \begin{pmatrix} 2 & 3 & 4 \\ -1 & 1 & -1 \end{pmatrix}$ and $\mathbf{B} = \begin{pmatrix} 7 & 1 \\ -1 & 1 \\ 2 & -3 \end{pmatrix}$ be two matrices. Find the matrix $\mathbf{BA}$

   (ii) Find the **domain** and the **range** of the function $g(x) = 2 - \sqrt{1 - 3x}$

   (iii) Prove the identity $\sin 3x = \sin x (4\cos^2 x - 1)$.

   (b) Find $\frac{dy}{dx}$ for each of the following:

   (i) $y = (x^2 - 1)^{\frac{5}{3}}$.

   (ii) $y = x^5 \tan x$.

   (iii) $y = \frac{3x-2}{1-4x}$.

5. (a) (i) Find the value of the limit $\lim_{x \to 2} \frac{2x^2 - 5x + 2}{x^2 + 5x - 14}$.

(ii) Given that $\mathbf{u} = 2i - 3j + k$, $\mathbf{v} = i + 4j + 5k$ and $\mathbf{w} = i + j - k$, find $\mathbf{u} \cdot (\mathbf{v} \times \mathbf{w})$.

(iii) Differentiate the function $g(x) = \frac{1}{x}$ from the **First Principle**

(b) Let $h(x) = \sqrt{3} \sin 2 \left(x + \frac{\pi}{4} \right)$ be a function.

(i) Determine the **period**, the **amplitude** and the **shift** of the function $h(x)$.

(ii) Solve the equation $h(x) = \frac{3}{2}$ where $-\frac{\pi}{4} \le x \le \pi$.

(iii) Sketch the graph of the function $h(x)$ in the interval $-\frac{\pi}{4} \le x \le \pi$

6. (a) (i) Express $\frac{5}{(1+3x)(1-2x)}$ into partial fractions.

(ii) Solve the equation $\cos x = \sin 2x$ for $0 < x < 2\pi$.

(iii) Sketch the graph of the function $g(x) = 2 - \sqrt{3x + 1}$

(b) (i) Prove using the principle of mathematical induction that $1 + 2 + \ldots + n = \frac{n(n+1)}{2}$ for all $n \in \mathbf{Z}^+$

(ii) The points $L(-3, 1)$ and $M(5, 3)$ are the end points of the diameter of a circle, with center N. Find the equation of the circle.

(iii) Find the cube roots of the complex number $2 + 2i$ in the form $r (\cos \theta + i \sin \theta)$.

7. (a) (i) Calculate the perpendicular distance from the point $P(6, -6)$ to the line $3x + 4y - 12 = 0$

(ii) Solve the equation $2^x - 9 + 8(2^{-x}) = 0$.

(iii) Sketch the graph of the function $f(x) = x^3 - 3x^2 - 9x + 2$

(b) Find the following integrals:

(i) $\int x^2 e^{4x^3} dx$.

(ii) $\int x^5 \ln x\, dx$.

(iii) $\int_0^3 x (x+1)^{\frac{1}{2}} \, dx$

End of examination.

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THE UNIVERSITY OF ZAMBIA
DEPARTMENT OF MATHEMATICS AND STATISTICS
MAT2110 FINAL EXAMINATION
3 JULY 2015
TIME: THREE HOURS

WRITE YOUR COMPUTER NUMBER ON EACH ANSWER BOOKLET
THERE ARE SEVEN QUESTIONS IN THIS EXAMINATION PAPER
ANSWER ANY FIVE QUESTIONS

1. (a) The equation

$$x^2 - xy + y^2 - 4x - 4y = 20$$

defines a conic section.
(i) Identify the conic section without transforming the equation. [2marks]
(ii) Locate its centre. [11marks]

(b) The parametric equations of a certain curve are given by

$$x = t^2 + 1, \quad y = 2t$$

(i) Identify the curve. [2marks]
(ii) Determine the curvature of the curve at the point $t = 1$. [5marks]

2. (a) Find the expansion of the polynomial $P(x) = 12x^2 + 8x^3$ about the point $a = -3/2$. [6marks]

(b) (i) Given the function $z = e^{xy} \sin(x + 2y)$, prove that $z_{xy} = z_{yx}$. [6marks]

(ii) Calculate the area enclosed by the curves $y = x^2$ and $y = 3x + 4$. [8marks]

3. (a) Find the antiderivative of the function

$$f(x) = \frac{x^2 - 37}{x^2 + x - 12}$$

[10marks]
(b). Plane Π_1 is given by $2x - 3y + 4z = 8$ while plane Π_2 is given by $x + 2y - cz = d$. The planes are perpendicular to one another and the point $(2, 1, -1)$ lies on Π_2.
(i) Calculate the values of c and d. [5marks]
(ii) Determine the distance of the point $(2, 1, -1)$ from Π_1. [3marks]
(iii) Determine the equation of the line perpendicular to Π_2 and passing through the point $(2, 1, -1)$. [2marks]

1

4. **(a)** **(i)** Show that the only point of intersection between the curves $x^2 + y^2 = 10$ and $y^2 = 3x$ is $(2, \sqrt{6})$. [3marks]

(ii) Determine the angle between the curves at this point. [5marks]

(iii) Use the differental arc length $ds = \sqrt{(dx)^2 + (dy)^2}$ to calculate the length along the circle $x^2 + y^2 = 10$ from the point $(2, \sqrt{6})$ to the point $(3, 1)$. [5marks]

(b) Solve the equation

$$x\frac{dy}{dx} + 3y = 6x^3$$

[7marks]

5. **(a)** The curve $y = x^2$ is rotated about the y axis. Considering only the portion between $y = 1$ and $y = 4$, determine the following.

(i) The volume of revolution. [3marks]

(ii) The surface of revolution. [4marks]

(b) **(i)** The equation of motion of a certain damped harmonic oscillator is

$$\frac{d^2x}{dt^2} - 2\frac{dx}{dt} + 5x = 0$$

Find the position as a function of time if the initial conditions are $x(t = 0) = 5$ and $v(t = 0) = 0$. [8marks]

(ii) Express the point of intersection of the line $x - y = 0$ and the parabola $y - 2x^2 = -1$ in polar coordinates. [5marks]

6. **(a)** The vertices of a triangle are at the points $A(1, 2, 4)$, $B(2, 2, 2)$ and $C(3, 0, 3)$.

(i) Determine the area of the triangle. [5marks]

(ii) Find the unit normal to the plane of the triangle. [2marks]

(iii) Find the perimeter of the triangle. [3marks]

(b) **(i)** Solve the differential equation $\left(\sqrt{x^2 - y^2} - 2y \right) dx + 2x dy = 0$ .. [6marks]

(ii) The velocity $v = dx/dt$ of a particle is given by $v = 8\sin^3 t \cos^2 t$. Find the position if $x(t = 0) = 0$. [4marks]

7. **(a)** **(i)** Find the sum of the series

$$\sum_{k=0}^{\infty} \left(\frac{5\sqrt{2}}{8} \right)^k$$

[4marks]
(ii) A particle travels along the curve $y^2 = 4x - 1$. Determine how close to the origin it passes. [6marks]

(b) (i) Determine the centre of mass of a metre rule of density $\mu(x) = 0.3x^2$ kg/m which is lying between $x = 0$ and $x = 1$ m. [4marks]
(ii) Find the Maclaurin series of $\ln\left[(1-x)(1-2x)\right]$. [6marks]

END OF EXAMINATION

The University of Zambia

Department of Mathematics and Statistics

MAT 2200 Linear Algebra

Final Examination – 2014/2015

Duration: Three (3) Hours

Instructions:

- There are SIX (6) questions in this paper. Answer any FIVE (5)

- Show all necessary work to earn full marks

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1. (a) Define the following

    i. A consistent system of linear equations

    ii. Row equivalent matrices

   (b) Find the values of k for which the system of linear equations

$$x - 2y + 3z = 2$$
$$x + y + z = k$$
$$2x - y + 4z = k^2$$

will have

    i. no solution

    ii. a unique solution

    iii. infinitely many solutions

   (c) Reduce the matrix $\begin{pmatrix} 3 & 0 & 1 & -2 \\ -2 & 1 & -1 & 3 \\ 4 & 0 & 1 & 1 \end{pmatrix}$ to reduced echelon form

2. (a) Define the following terms:

    i. An elementary matrix

    ii. A skew-symmetric matrix

   (b) Apply elementary row operations to find the inverse of the matrix $\begin{pmatrix} 1 & 0 & 1 \\ 2 & -1 & 0 \\ 0 & 3 & -5 \end{pmatrix}$

(c) If A is a square matrix, prove that $\frac{1}{2}(A + A^t)$ is symmetric and $\frac{1}{2}(A - A^t)$ is skew-symmetric

3. (a) Define the following

    i. A non-singular matrix

    ii. A homogeneous system of linear equations

(b) Evaluate the determinant $\begin{vmatrix} 2 & 0 & 3 & -1 \\ 1 & 0 & 2 & 2 \\ 0 & -1 & 1 & 4 \\ 3 & -2 & 1 & 5 \end{vmatrix}$

(c) If E is an elementary matrix, prove that $\det(E) = \det(E^t)$

4. (a) Define the following terms

    i. A subspace of a vector space

    ii. Linearly independent vectors

(b) Consider the subset $U = \{(a, b, c, d) : 2a - b + 3d = 0\}$ of $\mathbb{R}^4$

    i. Show that U is a subspace of $\mathbb{R}^4$

    ii. Find a basis for U

(c) If U and W are subspaces of a vector space V, prove that $U \cap V$ is a subspace of V

5. (a) Define the following

    i. A linear transformation

    ii. The kernel of a linear transformation

(b) Consider the map $T : \mathbb{R}^4 \to \mathbb{R}^4$ defined by $T(a, b, c, d) = (a + b, b + c, a + c, a + b - d)$

    i. Show that T is a linear transformation

    ii. Find the kernel of T

(c) If $T : V \to W$ is a linear transformation, prove that the kernel of T is a subspace of V

6. (a) Define the following terms

    i. An orthonormal basis

    ii. A quadratic form

(b) Apply the Gram-Schmidt orthogonalization procedure to the set $\{(1, 1, 1), (1, -1, 0), (1, 0, 2)\}$ to find an orthonormal basis for $\mathbb{R}^3$.

(c) State and prove the Cauchy-Swartz inequality

END OF EXAMINATION

The University of Zambia

Department of Mathematics & Statistics

2014 Academic Year Final Examinations

MAT2200 - Linear Algebra

Time Allowed: **Three (3)** Hours

Full Marks: 100

Instructions: • Attempt **Any Five (5)** questions. All questions carry equal marks.

• **Full credit** will only be given when **necessary work** is shown.

• Indicate your **computer number** on all answer booklets.

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1. (a) What is meant by a matrix in:

    i) echelon form;

    ii) row reduced echelon form.

    (b) Given matrix $A = \begin{bmatrix} 1 & 0 & -1 & 1 \\ 2 & 1 & -1 & 1 \\ -1 & 2 & 0 & 1 \\ 1 & 0 & 2 & -3 \end{bmatrix}$,

    i) Reduce A to echelon form;

    ii) Hence or otherwise solve the homogeneous system of linear equations with A as the matrix of coefficients.

    (c) Find the adjoint of $B = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 1 & -1 \\ 1 & 2 & 5 \end{bmatrix}$

2. (a) If $A = \begin{bmatrix} 1 & 2 & 4 \\ 0 & 1 & -1 \\ 1 & 0 & 2 \end{bmatrix}$, determine if A is invertible, and if so, find the inverse.

    (b) If $B = \begin{bmatrix} x^2 & x & 1 \\ 4 & 2 & 1 \\ 9 & -3 & 1 \end{bmatrix}$, for what value of x is B not invertible?

    (c) Find the eigenvalues of the matrix $C = \begin{bmatrix} 0 & 0 & 3 \\ 0 & 4 & 0 \\ 3 & 0 & 0 \end{bmatrix}$.

3. (a) Let S be the subspace of $\mathbf{R}^4$ and $S = \{(a+b, a-b, c, a+c) | a, b, c \in \mathbf{R}\}$. Find

    i) an orthonormal basis of S, relative to the standard basis.

    ii) extend this orthonormal set to a basis of $\mathbf{R}^4$

(b) Let $\beta = \{v_1, v_2, v_3\}$, where $v_1 = (1, 2, 0)$, $v_2 = (0, 5, 7)$, $v_3 = (-1, 1, 3)$.

i) Show that β is an $\mathbb{R}$-basis for $V_3(\mathbf{R})$.

ii) Find the co-ordinates of $(2, 3, 1)$ relative to this $\mathbb{R}$-basis.

4. (a) Let U and V be $\mathbb{K}$-spaces, and T a linear transformation of U into V, $T : U \to V$, define:

i) The image of T, (ImT);

ii) The kernel of T, $(KerT)$;

iii) Prove that ImT is a subspace of V.

(b) Let $T : \mathbb{R}^3 \to \mathbb{R}^3$ be a linear transformation defined by $T(x, y, z) = (x - y, x + 2y - z, 2x + y + z)$. Find the matrix representation of T, A_T relative to the standard basis for $\mathbb{R}^3$.

5. (a) Let V be the vector space of polynomials with inner product defined by $(f, g) = \int_0^1 f(t)g(t) \, \mathrm{d}t$. Let $f(t) = t + 2$, $g(t) = t^2 - 2t - 3$. Find

i) (f, g)

ii) $\|f\|$

(b) Suppose u and v are two non-zero vectors in $\mathbf{R}^3$. What does each of the following conditions imply about the linear independence or dependence of the set $\{u, v\}$?

i) $u = 3v$

ii) $(u, v) = 0$

iii) $au + bv = 0 \Rightarrow a = b = 0$

(c) Use the Gram-Schmidt Orthogonalization Procedure to obtain an orthogonal basis from $\{(1, -1, 1), (2, 1, 1), (1, 0, 1)\}$ in $V_3(\mathbf{R})$

6. (a) define a (real) orthogonal matrix A.

(b) Let $A = \begin{bmatrix} 1 & -1 & -1 \\ 0 & 3 & 2 \\ 0 & -1 & 0 \end{bmatrix}$.

i) Find the characteristic polynomial of A.

ii) By calculating the minimum polynomial of A, determine if A is diagonalizable (do not

diagonalize A).

(c) Let $B = \begin{bmatrix} 1 & 0 & 2 \\ 0 & 2 & 0 \\ 2 & 0 & -2 \end{bmatrix}$.

Find an orthogonal matrix P, and a diagonal matrix D such that $D = P^T BP$.

7. For the conic whose equation is given by $2x^2 - 2xy + 2y^2 - 2\sqrt{2}x + 4\sqrt{2}y = 8$

(a) Find

i) an orthogonal matrix P, which gives the principal axes of the conic;

ii) a diagonal matrix D such that $D = P^T AP$, where A is the matrix of coefficients of the quadratic terms;

iii) the equation of the conic in standard form.

(b) make a sketch of the conic, including old and new axes.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES

2014 ACADEMIC YEAR
FINAL EXAMINATIONS

MAT2602 INTRODUCTION TO STATISTICS

Time Allowed: Three (3) Hours

Instructions: 1.   Answer any **Five (5)** Questions
                2.   Show All Essential Working
                3.   Statistical Tables are provided
                4.   Calculators are Allowed

1.   (a)   Define the following:
             (i)   cluster sample.
             (ii)   parameter.

      (b)   The following observations represent masses, measured to the nearest gramme, of 30 washers:

3	8	10	13	1	5	2	20	26	4
19	13	6	14	7	24	2	17	30	23
16	7	12	9	34	22	15	10	5	11

             (i)   Construct a grouped frequency distribution table for the data using the classes $1 - 5, 6 - 10, \ldots$
             (ii)   Using the same classes in (i) above, construct a histogram and a frequency polygon on the same graph.
             (iii)   Describe the distribution of the data.

      (c)   Scores of students who take an actuarial science exam are normally distributed with mean 60 and standard deviation 5.
             (i)   Find the probability that the score of a randomly chosen student is below 52.
             (ii)   Find the probability that the mean score of 20 randomly chosen students lies between 57 and 61.
             (iii)   The probability that the mean score of 16 randomly chosen students is less than k is 0.0052. Find the value of k.

2.   (a)   State:
             (i)   two causes of non-response bias.
             (ii)   the central limit theorem.

(b) A random sample of eight employees is obtained from a certain company and the age of each employee (in years) is recorded below:

38   40   55   24   45   26   60   32

Assume that the ages of employees in the company are normally distributed.
- (i) Test whether there is sufficient evidence to indicate that the mean age of employees in the company exceeds 35 years. Use $\alpha = 0.05$.
- (ii) Construct a 95% confidence interval for the standard deviation of the ages of all employees in the company.
- (iii) Is the standard deviation of ages of employees in the company significantly different from 5? Explain.

(c) Batteries produced by a certain plant have a lifespan that is normally distributed with a standard deviation of 1.2 years. A random sample of 64 batteries from the plant had an average lifespan of 3.5 years.
- (i) Construct a 98% confidence interval for the mean lifespan of all batteries produced by the plant.
- (ii) Explain the meaning of the confidence interval in (i)
- (iii) How large a sample is needed in order to be 90% confident that the sample mean is within 0.2 years of the true mean?

3. (a) Define the following:
- (i) sampling distribution.
- (ii) type I error.

(b) A manager at Kalundu supermarket claims that the average weight of loaves of bread they sell is 400g. An official from the Zambia Consumer Protection Commission takes a random sample of 50 loaves of bread and decides he will reject the claim if the sample mean is less than 390g. The sample standard deviation of the 50 loaves is found to be 25g.
- (i) Explain how type II error would be committed in this context.
- (ii) Find the probability of committing a type I error.
- (iii) Find the probability of committing a type II error if the true mean weight is 381g.

(c) The mean height of a random sample of 10 students who take part in athletic activities at NRDC is 175cm with a standard deviation of 5cm while a random sample of 13 students who showed no interest in athletics had a mean of 170cm and a standard deviation of 7cm. Assume that the heights are normally distributed.
- (i) Are students who take part in athletic activities taller? Test at the 1% level of significance, assuming equal variances.
- (ii) Is the assumption of equal variances made in (i) valid? Test at the 5% level of significance.

4. (a) Define the following:
 (i) power of a test.
 (ii) proportional stratified sample.

(b) A random sample of 400 people from Muchinga Province showed that 260 had surnames beginning with the letter M while a random sample of 300 from Western Province showed 174 with surnames starting with M.
 (i) Construct a 95% confidence interval for the proportion of people whose surnames start with the letter M in Muchinga Province.
 (ii) Is there any evidence that 55% of the people in Muchinga Province have surnames starting with the letter M? Explain.
 (iii) At the 5% level of significance test whether the results of the two provinces are significantly different.

(c) The following are data on 150 chickens, divided into two groups according to breed and into three groups according to yield of eggs:

		Yield		
		High	Medium	Low
Breed	A	45	29	28
	B	27	15	6

Test whether these data are consistent with the hypothesis that the yield of eggs is not affected by the type of breed. Use a 5% level of significance.

5. (a) Define the following:
 (i) response bias.
 (ii) systematic sample.

(b) A corporation owns three stores A, B and C, located in three different towns. The manager of the corporation claims that the daily mean number of sales is the same for the three stores. A sample yielded the following results:

A	B	C
33	38	64
40	43	46
24	27	42
48		48
36		

 (i) What design was used in the experiment?
 (ii) Write down a model for the above experiment. Explain all the terms in your model and state all the assumptions.
 (iii) Test the manager's claim at the 2.5% significance level.

(c)   A salesman for a shoe company claims that runners would be faster, on the average, with the company's brand of sneakers. To test the claim, eight runners ran 100m races, on different days, using sneakers supplied by the salesman and those supplied by the school and the following results were obtained:

| School sneakers | 11.4 | 12.5 | 10.8 | 11.7 | 10.9 | 11.8 | 12.2 | 11.7 |
| Salesman's sneakers | 10.8 | 12.3 | 10.7 | 12.0 | 10.6 | 11.5 | 12.1 | 11.2 |

(i)   Test the salesman's claim using a 5% significance level.
(ii)   State the assumption(s) required for the test in (i) to be valid.

6.   (a)   Define the following:
(i)   inferential statistics.
(ii)   statistical hypothesis.

(b)   The owner of a large company claims that 10% of the employees in the company earn less than K25,000 per annum, 30% earn at least K25,000 but less than K30,000, 30% earn at least K30,000 but less than K35,000 and 30% earn at least K35,000. At the 10% level of significance, test whether the following sample data give sufficient evidence to reject the owner's claim.

Category	Number of employees
Less than K25,000	19
At least K25,000 but less than K30,000	56
At least K30,000 but less than K35,000	51
At least K35,000	40

(c)   A study was conducted to compare the yields of four varieties of maize v_1, v_2, v_3 and v_4. Three farms of equal size, available for the study, were divided into 4 equal plots where each variety was planted and the following results were obtained:

Farm 1		Farm 2		Farm 3
$v_1 = 74$		$v_2 = 67$		$v_4 = 73$
$v_3 = 74$		$v_4 = 72$		$v_2 = 69$
$v_2 = 68$		$v_1 = 73$		$v_3 = 78$
$v_4 = 71$		$v_3 = 76$		$v_1 = 75$

(i)   What design was used in the study?
(ii)   Write down a model for the above study. Explain all the terms in your model and state all the assumptions.
(iii)   Prepare an ANOVA table for the study.

(iv)   Test at the 5% level of significance whether the varieties give the same yield. State your hypotheses and conclusions clearly.

(v)   Test at the 5% level whether the farms give the same yield. State your hypotheses and conclusions clearly.

END OF EXAMINATION

The University of Zambia

Department of Mathematics & Statistics

2014/15 Sessional Examinations - July 2015

MAT 3110 - ENGINEERING MATHEMATICS II

Time allowed : Three (3) Hours   Full marks : 100

Instructions:

1. Attempt any **Four (4)** questions from **section A** and **One(1)** question from section B.

2. All questions carry equal marks.

3. **Full credit** will only be given when **necessary work** is shown.

4. Indicate your **computer number** on all answer booklets.

5. Normal distribution tables and Laplace transformation tables are provided.

This paper consists of 5 pages of questions.

SECTION A

1. **(a)** Solve the simultaneous equations

   $$Dx + Dy + y = t$$
   $$D^2x + 3x + D^2y + 7y = e^{2t}$$

   such that $Dx = -\frac{19}{3}$ and $Dy = 3$ when $t = 0$.

   (b) Using the substitution $t^2 = x$, find the general solution of the differential equation

   $$4x\frac{d^2y}{dx^2} + 2(1 - \sqrt{x})\frac{dy}{dx} - 6y = e^{3\sqrt{x}}.$$

   (c) Solve $y'(t) + y(t) - \int\limits_{0}^{t} y(\nu)\sin(t - \nu)d\nu = -\sin t$, given that $y(0) = 1$.

2. **(a)** Using the convolution theorem solve the initial value problem

   $$y'' + 2y' + 2y = \sin \alpha t; \qquad y(0) = 0, \quad y'(0) = 0.$$

   (b) Using the substitution $y = zx^n$, show that the equation

   $$x^2D^2y + (4x + 3x^2)Dy + (2 + 6x + 2x^2)y = x$$

   can be reduced to one possessing constant coefficients for a suitable value of n. Hence

   (i) Find the value of n.

   (ii) Find the general solution of the equation.

   (c) Use the convolution theorem to obtain a formula for the solution to the problem

   $$y'' - y' + y = g(t); \qquad y(0) = -1, \quad y'(0) = 1.$$

3. **(a)** Given the periodic function $f(x) = |x|$ $(-3 < x < 3)$.

   (i) Determine whether $f(x)$ is even or odd. Hence, find the fourier series of $f(x)$.

   (ii) Use your result in (i) to evaluate

   $$1 + \frac{1}{3^2} + \frac{1}{5^2} + \frac{1}{7^2} + \dots.$$

   (b) (i) Find the Fourier integral representation of the function

   $$f(x) = \begin{cases} 1, & \text{if } |x| < 1 \\ 0, & \text{if } |x| > 1 \end{cases}.$$

2

(ii) Use the result in (i) to evaluate $\int_0^\infty \frac{\sin \omega}{\omega} d\omega$.

(c) (i) Sketch the solid E bounded by the paraboloids $z = 8 - x^2 - y^2$ and $z = x^2 + y^2$.

(ii) Use a triple integral to find the volume of the solid E in (i) above.

4. **(a)** Use the method of separation of variables to find the deflection $u(x, t)$ of the vibrating string satisfying

$$u_{tt} = 9u_{xx}, \quad 0 < x < \pi, \quad t > 0,$$

$$u(0, t) = u(\pi, t) = 0, \ t \geq 0, \quad u(x, 0) = \sin x + 2 \sin 3x,$$

$$u_t(x, 0) = 4 \sin 2x + \sin 4x, \ 0 \leq x \leq \pi.$$

Hint: The solution of $u_{tt} = c^2 u_{xx}, \quad 0 < x < L, \quad t > 0$, satisfying

$u(0, t) = u(L, t) = 0$ is $u(x, t) = \sum_{n=1}^\infty (a_n \cos \lambda_n t + b_n \sin \lambda_n t) \sin \frac{n\pi}{L} x$ where $\lambda_n = \frac{cn\pi}{L}$

(b) (i) Evaluate

$$\int_0^1 \int_{\arcsin y}^{\frac{\pi}{2}} \sqrt{1 + \cos^2 x} \, \cos x \, dx dy.$$

Hint: Sketch the region of integration.

(ii) Find parametric equations for the tangent line to the curve of intersection of the surfaces $f(x, y, z) = x^2 + y^2 - 2 = 0$ and $g(x, y, z) = x + z - 4 = 0$ at the point $P(1, 1, 3)$.

(c) Use the transformation $x = \frac{1}{4}(u + v)$, $y = \frac{1}{4}(u - 3v)$ to evaluate

$\int \int_R (4x + 8y) dA$, where R is the parallelogram with vertices $(-1, 3)$, $(1, -3)$, $(3, -1)$ and $(1, 5)$.

5. **(a) (i)** State the Fundamental Theorem of Line Integrals.

(ii) Show that $\mathbf{F}(x, y) = (2x \cos y)\mathbf{i} - (x^2 \sin y)\mathbf{j}$ is exact and find the potential function f of $\mathbf{F}$. Hence,

(iii) Evaluate the line integral $\int_C \mathbf{F} \cdot d\mathbf{r}$ where $\mathbf{F}(x, y) = (2x \cos y)\mathbf{i} - (x^2 \sin y)\mathbf{j}$ and C is the curve with parametric equations $x = e^{t-1}$, $y = e^{2t-2} \sin(\frac{\pi}{t})$; $1 \leq t \leq 2$.

(b) (i) Use Stoke's theorem to evaluate $\int_C \mathbf{F} \cdot d\mathbf{r}$ where

$\mathbf{F}(x, y, z) = xy\mathbf{i} + 2z\mathbf{j} + 3y\mathbf{k}$, and C is the curve of intersection of the plane $x + z = 5$ and the cylinder $x^2 + y^2 = 9$.

(ii) Evaluate $\int_C (x^2 y^3 - \sqrt{x})dy$ where C is the arc of the curve $y = \sqrt{x}$ from $(1,1)$ to $(4,2)$.

(c) (i) State the Divergence theorem.

(ii) Use the Divergence theorem to evaluate $\int_C \mathbf{F} \cdot d\mathbf{S}$ where

$\mathbf{F}(x,y,z) = xy\mathbf{i} + (y^2 + e^{xz^2}\mathbf{j} + \sin(xy)\mathbf{k}$, and S is the surface of the region E bounded by the parabolic cylinder $z = 1 - x^2$ and the planes $z = 0$, $y = 0$, $y + z = 2$.

SECTION B

6. (a) (i) A random variable X has probability function

$$p(0) = 0.1, p(1) = 0.3, p(2) = 0.4, p(3) = 0.2.$$

Find E(X) and Var(X).

(ii) If Z is normally distributed with mean 0 and variance 1, find $P(z < -2.92)$ and $P(-0.074 < z < 1.748)$.

(iii) Find z_1 such that $P(z < z_1) = 0.1764$ and $P(z > z_1) = 0.0764$.

(b) A manufacturer produces light bulbs which are tested in the following cases:

I   A first sample of five shows no faulty bulbs;   II   A first sample of five shows one or more faulty bulbs but a second sample of five shows no faulty bulb.

(i) What is the probability that a batch is accepted if 3 percent of the bulbs in it are faulty?

(ii) Using an operating characteristic (OC) curve analyse this sampling plan in more details.

(iii) Verify that the sampling plan given above can be written as:

$$L(p) = 2(1-p)^5 - (1-p)^{10}.$$

(iv) State in practice the two conflicting aims which have to be balanced between a manufacturer and a customer

4

7. (a) A large number of screw drivers from a trial production run is inspected. It is found that the cellulose acetate handles are defective in 1 percent of the screw drivers and that the chrome steal blades are defective in 1.5 percent of the screw drivers, with the defects occurring independently. What is the probability that a sample of 80 screw drivers contains;

(i) No defective screw driver handles?

(ii) More than two defective screw drivers

(b) The marks of 500 candidates in an examination are normally distributed with a mean mark of 45 marks and a standard deviation of 20 marks.

(i) Given that the pass mark is 41, estimate the number of candidates who passed the examination.

(ii) If 5 percent of the candidates obtain a distinction by scoring x marks or more, estimate the value of x.

END OF EXAM!

UNIVERSITY OF ZAMBIA

DEPARTMENT OF MATHEMATICS AND STATISTICS

MAT3300 - REAL ANALYSIS

2014/2015 ACADEMIC YEAR EXAMINATIONS

TIME ALLOWED: 3 HOURS   DATE: July 3, 2015

INSTRUCTIONS
There are Six (6) questions in this paper.
Attempt any Five (5) questions.

1. (a)

    (i) State Rolle's Theorem for a function $f : [a, b] \to \mathbf{R}$.

    (ii) Let f and g be real valued functions defined and continuous on the closed interval $[a, b]$. If both f and g are differentiable on (a, b) with $g'(x) \neq 0$ for all $x \in (a, b)$, show that there is a point c with $a < c < b$ such that $\frac{f(b)-f(a)}{g(b)-g(a)} = \frac{f'(c)}{g'(c)}$.

    (b) Let $f : \mathbf{R} \to \mathbf{R}$ and be defined by $f(x) = x^2 \sin \frac{1}{x}$ if $x \neq 0$ and $f(x) = 0$ if $x = 0$. Show that f is differentiable on $\mathbf{R}$.

    (c)

    (i) Define the local minimum of a function f defined on a set $[a, b]$.

    (ii) Prove that if f has a local minimum at a point $c \in (a, b)$ and if $f'(c)$ exists, then $f'(c) = 0$.

2. (a)

    (i) State the Bolzano-Weiestrass Theorem.

    (ii) Prove that if F is a closed subset of $\mathbf{R}$, (x_n) is a sequence in F, that is, $x_n \in F$ for all n and $x_n \longrightarrow x$, then $x \in F$.

    (b) Let A and B be subsets of a set $E \subset \mathbf{R}$, show that if A is closed in E, then $A \cap B$ is closed in B.

    (c)

    (i) Define an open covering of a set $A \subset \mathbf{R}$.

    (ii) Let $A = \{x_1, x_2, \ldots, x_m\}$ be a finite set, prove that A is compact.

3. (a) Let X be a subset of real numbers.

    (i) Define the separation of X.

    (ii) If A is a non-empty proper subset of X such that A is both open and closed in X, show that X is not connected.

  (b) Let A be a subset of real numbers and let $f : A \to \mathbf{R}$ be an increasing function on A. Given that $c \in A$ is an interior point of A, prove that

$\lim_{x \to c^-} f(x) = \sup\{f(x) : x \in A, x < c\}$.

  (c)

    (i) Let f be a continuous function on a closed and bounded interval $[a, b]$ and differentiable on (a, b). If $\mid f'(x) \mid \le M$ for all $x \in (a, b)$ and some $M > 0$, prove that f is of bounded variation on $[a, b]$.

    (ii) Let $f(x) = x^2 \cos \frac{1}{x}$ if $x \ne 0$ and $f(0) = 0$. Show that f is of bounded variation on $[0, 1]$.

4. (a)

    (i) Define the Riemann-Stieltjes integral of a bounded function f defined on the interval $[a, b]$

    (ii) Let $f, g \in R[a, b]$ such that $f \le g$ on $[a, b]$. Show that $\int_a^b f \le \int_a^b g$.

  (b) Let $f : \mathbf{R} \to \mathbf{R}$ be differentiable at a point $x_0 \in \mathbf{R}$. Prove that f is continuous at x_0.

  (c)

    (i) State the Second Fundamental Theorem of Calculus.

    (ii) A function $f : [0, 1] \to \mathbf{R}$ is defined by $f(x) = x^2 \sin \frac{1}{x^2}$ if $x \in (0, 1]$ and $f(x) = 0$ if $x = 0$. Show that f does not satisfy the equation $\int_a^b f'(x)dx = f(b) - f(a)$

5. (a)

    (i) Let $f : X \to Y$. Define the direct image of $A \subset X$ under f and the inverse image of $B \subset Y$ under f.

    (ii) Prove that if A is a compact subset of real numbers and $f : A \to \mathbf{R}$ is a continuous function on A, then the set $f(A)$ is compact.

  (b) Let $f_1, f_2, \ldots, f_n, \ldots$ be a sequence of functions defined on a set $E \subset \mathbf{R}$ with the property that given any $\epsilon > 0$ there is a positive integer $N(\epsilon)$, depending only on ϵ such that if $n, m > N(\epsilon)$ then $\mid f_n(x) - f_m(x) \mid < \epsilon$ for all $x \in E$. Prove that the sequence converges uniformly on E.

  (c)

    (i) Let $f_1, f_2, \ldots, f_n, \ldots$ be a sequence of functions defined on a set $E \subset \mathbf{R}$. Show that if $f_n \longrightarrow f$ uniformly on E then $\lim_{n \to \infty} [\sup_{x \in E} \mid f_n(x) - f(x) \mid] = 0$.

    (ii) Given the sequence of functions $f_n(x) = \frac{2 + x^n}{3 + x^n}$ for $0 \le x < 1$, $n = 1, 2, 3, \ldots$, determine whether or not the sequence converges uniformly on $[0, 1)$.

6. (a)

(i) Define the upper Riemann integral of a bounded function f defined on a closed and bounded interval $[a, b]$.

(ii) Let

$$f(x) = \begin{cases} \sqrt{1 - x^2} & \text{if } x \text{ is rational} \\ 1 - x & \text{if } x \text{ is irrational.} \end{cases}$$

Find the upper Riemann integral and the lower Riemann integral of f over the interval $[0, 1]$.

(b) Let f be continuous and bounded on the closed and bounded interval $[a, b]$. Show that there is a point c with $a < c < b$ such that $\int_a^b f(x)dx = (b - a)f(c)$.

(c) Determine the convergence or divergence of each of the following integrals:

(i) $\int_0^\infty e^{-\alpha x}dx$, $\alpha \neq 0$.

(ii) $\int_a^\infty \frac{1}{x^p}dx$, $0 < a < x$.

End of examination.

The University of Zambia

Department of Mathematics and Statistics

MAT4212 Module and Field Theory Final Examination 2014/2015

Duration: Three (3) Hours

Instructions:

- There are SIX (6) questions in this paper. Answer any FIVE (5)

- Show all necessary work to earn full marks

---

1. (a) Define the following:

    i. The splitting field of a polynomial.

    ii. A perfect field.

   (b) Prove that if $f(x)$ is an irreducible polynomial over a perfect field, then it has no multiple zeros.

   (c) i. Find the splitting field of $x^4 + 2$ over $\mathbb{Z}_3$.

    ii. Show that every finite field is a perfect field.

2. (a) Define the following terms:

    i. An algebraic extension.

    ii. A finite extension.

   (b) Suppose that E, F, K are fields. Prove the following:

    i. If K is an algebraic extension of E and E is an algebraic extension of F, then K is an algebraic extension of F.

    ii. If K is a finite extension of E·and E is a finite extension of F, then K is a finite extension of F and $[K : f] = [K : E][E : F]$.

    iii. Given that E is the splitting field for $x^4 + 5x^2 + 6$ over $\mathbb{Q}$, find $[E : \mathbb{Q}]$.

3. (a) Define the following:

    i. The automorphism group of an extension field.

    ii. A polynomial solvable by radicals.

   (b) Let F be a field of characteristic 0 and let $f(x) \in F[x]$. Suppose that $f(x)$ splits in $F(a_1, a_2, ..., a_t)$, where $a_1^{n_1} \in F$ and $a_i^{n_i} \in F(a_1, a_2, ..., a_{i-1})$ for $i = 2, ..., t$. Let E

be the spitting field for $f(x)$ over F in $F(a_1, a_2, ..., a_n)$. Prove that the Galois group $\text{Gal}(E/F)$ is solvable.

(c) Let E be the splitting field for $x^4 + 3x^2 + 2$ over $\mathbb{Q}$. Write down the lattice of subfields of E and the lattice of subgroups of $\text{Gal}(E/\mathbb{Q})$.

4. (a) Define the following:

 i. An R-module.

 ii. An R-module homomorphism.

 (b) Let N, K be submodules of an R-module M. Prove that K is a submodule of $N + K$ and $N \cap K$ is a submodule of N, and $\dfrac{N + K}{K} \cong \dfrac{N}{N \cap K}$.

 (c) Show that every ring with unity R is an R-module.

5. (a) Define the following terms:

 i. A finitely generated module.

 ii. The direct sum of modules.

 (b) Let M be a non-trivial R-module. Prove that the following statements are equivalent:

 i. M is finitely generated and free with basis $\{a_1, a_2, ..., a_n\}$.

 ii. There exist $a_1, a_2, ..., a_n \in M$ such that for all $m \in M$ there exist unique $r_1, r_2, ..., r_n \in R$ with $m = r_1 a_1 + r_2 a_2 + \cdots + r_n a_n$.

 iii. There exist $a_1, a_2, ..., a_n \in M$ such that $M = Ra_1 \oplus Ra_2 \oplus \cdots \oplus Ra_n$.

 (c) If R is a field, show that every vector space over R is a finitely generated and free R-module.

6. (a) Define the following terms:

 i. A torsion element.

 ii. A finitely generated and free R-module.

 (b) Let M be an R-module and K a submodule of M such that M/K is finitely generated and free. Prove that there exists a submodule N of M such that $N \cong M/K$.

 (c) Let R be an integral domain and M an R-module.

 i. If N is a submodule of M, show that M is torsion if and only if both M/N and N are torsion.

 ii. If M is finitely generated, show that either M is torsion or M contains a finitely generated and free submodule N such that M/N is torsion.

END OF EXAMINATION

THE UNIVERSITY OF ZAMBIA
2014/2015 ACADEMIC YEAR FINAL EXAMINATIONS
MSE 3060: CHEMISTRY TEACHING METHODS

Time: Three (3) Hours   **Marks: 100**

INFORMATION

1. The question paper has **six (6)** questions
2. Each question carries a maximum of **twenty [20]** marks
3. The question paper has **three (3)** pages only
4. Mark allocation is shown in brackets[ ]

INSTRUCTIONS

- Answer question **one (1)** and any other **four (4)** questions

---

QUESTION 1

In your first class at your new school you obtain a mixture of a metal carbonate, MCO_3, and its oxide, MO, and heat until it releases carbon dioxide gas and is converted completely to the metallic oxide, MO.

a) List two objectives which will encourage high order thinking amongst your pupils.
[2]

b) If a 0.6500 g sample of MCO_3 and MO forms 0.1575 L of carbon dioxide gas at 25.0 °C and a barometric pressure of 700.0 mm Hg, determine the number of moles of CO_2 formed.
[2]

c) When the 0.3891 g of MO resulting from the process in 1 (c) is titrated with 0.500 M HCl, 38.60 mL are required. Determine the number of moles of MO in 0.3891 g.   [2]

d) Determine the atomic mass of the metal M and give its symbol.   [3]

e) Determine the mole percentages of MCO_3 and MO in the original sample.   [4]

f) Explain a real-life situation or problem where the knowledge gained by doing this experiment can be utilised.   [4]

g) If your school lacks apparatus and improvisation is not possible, explain how you can use other teaching/learning aids to teach this topic interactively?   [3]

Additional information
$R = 8.314$ J/mol.K; $R = 0.0821$ L.atm/mol.K; 0 °C = 273.15 K; 1 atm = 760 mm Hg

QUESTION 2

In practical classes, the teacher of chemistry has a responsibility to inform pupils of hazards associated with the use of chemicals.

Discuss ten (10) key safety points to note when handling chemicals.   [20]

QUESTION 3

There are as many ways to structure a chemistry lesson plan as there are different teaching situations, and no single plan can serve as a model for all situations.

    a) Using a basic format, write a short (40 minute) lesson plan on any ordinary level chemistry topic of your choice. [10]

    b) Explain:

        (i)   How the lesson plan you have written would serve as a guide to effective instruction. [6]

        (ii)   Three consequences of going to teach a chemistry lesson without a lesson plan. [3]

        (iii)   How you can overcome the situation of running out of activities when a chemistry class period is only half-way over? [1]

QUESTION 4

    a) Give the meaning of the following in relation to teaching of chemistry

        i.   Direct teaching. [2]

        ii.   Indirect teaching. [2]

    b) Cite two (2) situations when direct teaching is appropriate during chemistry teaching. [2]

    c) Why is the use of indirect teaching encouraged than direct teaching? [2]

    d) There are various strategies that a teacher can use to teach chemistry at secondary school level. One of them involves engaging pupils in experimental activities.

        i.   Discuss the value of engaging pupils in experiment work during chemistry lessons. [6]

        ii.   Describe three (3) challenges you are likely to encounter in your effort to implement the strategy cited in (d) above. [3]

        iii. Explain how the challenges you have given in (ii) above can be minimised. [3]

QUESTION 5

    a) Choose one specific topic from the Zambian Chemistry School Certificate syllabus and use it to illustrate how you would appropriately teach the topic using each of the following teaching approaches:

        i.   Whole class [2]

        ii.   Small Group [2]

        iii. Individualised [2]

    b) State one specific topic in the Zambian Chemistry School Certificate syllabus. [2]

    c) Use the topic identified in 5(b), to:

        i.   Illustrate how you would achieve the teaching of concepts from the cognitive domain perspective. [4]

        ii.   Show how you would ensure that your pupils acquire the psychomotor skills. [4]

        iii. Describe how you would help your pupils develop appropriate values and attitudes in the affective domain. [4]

QUESTIONS 6

a) List channels to learning. [3]

b) Outline elements of learning. [3]

c) Why are learning theories an important element of chemistry teacher's pedagogical skills? [4]

d) Complete the Table [6]

Learning Theory	What is its meaning?	When do you apply it?
Behavioural		
Cognitive		
Constructivism		

e) Clearly explain giving concrete examples, how any two of the following Microsoft Office Applications Software can be used in a teaching and learning situation: MS Excel, MS Publisher, and MS PowerPoint. [4]

End of Examination

THE UNIVERSITY OF ZAMBIA

2014/2015 ACADEMIC YEAR FINAL EXAMINATIONS

MSE 9060: ADVANCED CHEMISTRY TEACHING METHODS

TIME: Three (3) hours   Marks: 100

INFORMATION

1. There are six **(6)** questions in this Examination Paper.
2. The marks for each question are indicated in square brackets [ ].
3. Each question has a possible maximum mark of 20.

INSTRUCTIONS

1. Answer Question one **(1)** and;
2. Any other four **(4)** questions. You will have answered a total of five **(5)** questions.

_____.

1. For each of the following; word searches, puzzles, anagrams and spider diagram:
   (a) Say what it is.   [4]
   (b) Explain how you can use it to teach the mole concept.   [16]

2. (a) What is a research hypothesis and why is it used in a research proposal?   [4]
   (b) Why is a conceptual framework important for a study?   [6]
   (c) Distinguish between qualitative and quantitative research methodology.   [10]

3. (a) What are science process skills and why are they important in the teaching and learning of chemistry?   [4]
   (b) Compare and contrast among the following terms; an analysis, an evaluation and a conclusion in the context of a laboratory report write up.   [6]
   (c) Why is a Conversion Teaching Strategy in Chemistry more productive in terms of learning attainment than Teacher exposition?   [10]

4. (a) Why is Global Warming a cross-cutting issue in chemistry teaching and learning?
                                                                                     [6]
   (b) Show how Global warming can be integrated in the teaching and learning of chemistry.   [4]
   (c) Explain the impact of HIV/AIDS issue on chemistry teaching and learning.   [10]

5. (a) What do you understand by the concept of Continuing Professional
    Development (CPD) for a Chemistry Teacher? [4]
    (b) Show how each of the following has contributed to the improvement of the
    teaching and learning of chemistry in Zambia.
    (i) AIEMS [2]
    (ii) ZASE [2]
    (iii) JETS [2]
    (c) Outline five (5) challenges children with SEN (Special Education Needs) face in
    the teaching and learning of chemistry and show how you can go round it to maximise
    the child's access to chemistry knowledge. [10]

6. As head of the science department you will be expected to initiate change and
    consider change initiated by other members in your department.
    (a) Using four headings, explain what causes resistance to change. [8]
    (b) Explain four (4) determinants of the chemistry curriculum. [12]

END OF EXAMINATION

All questions carry equal marks. The marks are shown in brackets. <u>Question 1 is compulsory</u>. Attempt <u>four more</u> questions. Clearly indicate on the answer script left column on the cover page the questions you have answered.

Time : Three hours.   **Maximum marks = 100.**

Do not forget to write your computer number clearly on the answer book as well as on the answer sheet for Question 1. Tie them together.
==

Wherever necessary use:

$g = 9.8 m/s^2$ 1 metric ton = 1000 kg

$P_A = 1.01 \times 10^5 N/m^2$

1 cal. = 4.18 J

$C_{water} = 4184 J/kg.^oC$

$R = 8314 J/kmol.K$

$k = 1.381 \times 10^{-23} J/K$ (Bolzmann's constant)

$\varepsilon_0 = 8.85 \times 10^{-12} C^2/Nm^2$

$c = 3 \times 10^8 m/s$

$h = 6.63 \times 10^{-34} J\text{-}s$

1 pascal = 1 N/m^2

$1eV = 1.6 \times 10^{-19} J$

$e = 1.6 \times 10^{-19} C$

$m_e = 9.11 \times 10^{-31} kg$

$k = 9 \times 10^9 Nm^2/C^2$

$\mu_0 = 4\pi \times 10^{-7} N/A^2$

$\rho_{water} = 1000 kg/m^3$

$G = 6.67 \times 10^{-11} Nm^2/kg^2$

The University of Zambia
Physics Department
University Examinations 2014/2015
PHY1010 Introductory Physics

Answer sheet for Question 1

<u>**Computer Number only**</u> ....

Q1. Put a cross (×) or tick mark (√) in the appropriate box.

If it is on the dividing line, it will not be counted.

	a	b	c	d
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				

Do NOT write here.
For official use only:

	Number of parts N	Factor f	Marks f × N
Correct		2	
Wrong		–(0.67)	
Net Marks:			

Attach this sheet firmly with the main answer book. If you lose this sheet, you will lose the marks for Question 1!!

Question 1 : For <u>each</u> correct answer, 2 marks will be given. For <u>each</u> wrong answer, 0.67 will be deducted. For no answer, zero mark will be given. The minimum total mark for Question 1 is zero.]

(A) Periodic motion is a motion:

    a) under the influence of an elastic restoring force:
    b) that repeats itself in equal intervals of time.
    c) back and forth over varying paths
    d) with constant acceleration

(B) An ideal gas is heated at constant volume from 300 K to 600 K. If the original pressure was 1.5 atm, the new pressure will be:

    a) doubled
    b) halved
    c) less than doubled
    d) the same

(C) At constant temperature the pressure and volume of a gas are:

    a) inversely proportional
    b) independent of one another
    c) directly proportional
    d) constant

(D) A modulus of elasticity is a ratio of:

    a) stress to deformation
    b) stress to strain
    c) strain to stress
    d) elongation to deformation

(E) The product of force times the perpendicular distance between some point and the line of application of the force is:

    a) the moment of inertia acting on the object
    b) the angular momentum of the object
    c) torque
    d) lever arm

(F) An astronaut whose total mass is 100 kg ejects 1.0 g of gas from his propulsion pistol at a speed of 50 m/s. His recoil speed is:

    a) 0.5 m/s
    b) 5×10^{-4} m/s
    c) 5×10^{-3} m/s
    d) 5×10^{-2} m/s

(G) A Carnot engine has the same efficiency between 100 K and 500 K as between T K and 1000 K, T being the lower temperature (cold reservoir). The value of T is:

    a) 100 K
    b) 500 K
    c) 200 K
    d) 300 K

(H) An acceleration which is constant in time results in a velocity which is:

    a) depends inversely on time
    b) is a quadratic function of time
    c) changes linearly with time
    d) remains constant

(I) A vector quantity defined as a change in velocity of a moving object during a given time interval divided by the time interval is:

    a) average speed
    b) average velocity
    c) instantaneous acceleration
    d) average acceleration

(J) Two boys are standing at the edge of a vertical cliff. One boy fires an air-gun pellet horizontally at the same time the second boy drops a pellet at the edge of the cliff. The shot pellet and the dropped pellet start at the same height from the bottom of the cliff. The time taken for the pellets to reach the ground:

    a) is greater for the one shot off the cliff horizontally
    b) depends on the initial velocity of the one shot off the cliff
    c) is shorter for the one shot off the cliff horizontally
    d) is the same for both

Attempt any four questions from the following:

Q 2 (a) A ball at the end of a 2.0 m long string swings in an arc as shown below. The ball's speed is 3.5 m/s as it passes through its lowest position.

    i)   To what height h above this position will it rise before stopping?
    ii) What angle does the string make with the vertical when ball is a at the highest position?   **[9]**
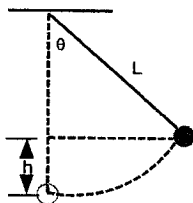
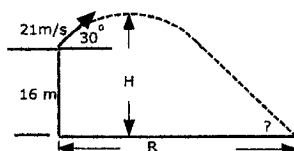**(b)** A stone is thrown at a velocity of 21 m/s at 30° aboe the horizontal from the top of a building 16 m high as shown below. Find:

i) the time of flight,
ii) the horizontal range, and
iii) the maximum height *H* from the ground. **[11]**

Q.3 (a) An ideal refrigerator, which is Carnot engine operating in reverse, operates between a freezer temperature of -9 °C and a room temperature at 25 °C. In a period of time, it absorbs 120 J from the freezer compartment. How much heat is rejected to the room? **[10]**

(b) A hoop of radius 0.06 m starts from rest and rolls down a slope without slipping.

i) Find its linear and angular speed when it reaches a point 0.50 m vertically lower than its starting point. ($I = mr^2$)
ii) Find the linear and angular speed in (i) above if the slope were perfectly smooth so that the hoop just slipped and does not roll. **[10]**

Q.4(a) A pool ball *A* of mass m_a = 0.400 kg moving with a speed of v_a = 1.8 m/s along the positive *x*-axis strikes another ball *B* initially at rest of mass m_b = 0.500 kg. The collision results in ball *A* being deflected off at an angle of 30° with respect to the positive *x*-axis with a speed of 1.10 m/s.

i) Write down the equations expressing the conservation of momentum in the *x* and *y* directions separately.
ii) Solve the equations for the speed of ball *B* after the collision and the angle θ_b. **[10]**

(b) A car of mass 100 kg moving at 20 m/s on a horizontal road is brought to rest by braking over a distance of 25 m.

i) Find the average braking force.
ii) Now the same car moves up a slope with the same velocity. The slope rises by 1 m for a horizontal distance of 20 m. The retarding force exerted by the slope on the car is 100 N. Find the power which the engine develops. **[10]**

**Q.5 (a)** Steam flows into a condenser at the rate of 5 m³/min. The density of steam is 1.50 kg/m³ and its input temperature is 160 °C. The steam is cooled to 100 °C and then condensed into water at 100 °C. The specific heat capacity of steam is 0.48 cal/g.°C and the heat of vaporization is 540 cal/g. Calculate the amount of heat added to the condenser each minute. **[9]**

(b) A sample of air is compressed from a pressure of 2 atm to 5 atm. The original volume and temperature are 20 litres and 17 °C respectively. Next the air is expanded back adiabatically to its original pressure of 2 atm. Find the final volume (in litres) and the temperature of the gas. (Take air to be essentially composed of oxygen and nitrogen only) **[8]**

(c) Explain the three modes of heat transfer. **[3]**

Q.6 (a) Find the resultant of the following two displacements: 1 m along the positive x-axis, 2 m at 40° and 4 m at 127°; the angles being relative to the positive x-axis. **[10]**

(b) A uniform bar of weight W_1 = 35 N is supported at its ends as shown below. A block of weight W_2 = 10 N is placed one quarter distance from one end. What are the magnitudes of the forces N_1 and N_2 exerted by the supports?
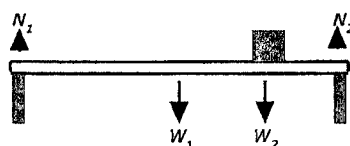

[10]

Q.7 (a) A man slides a crate at constant velocity along a horizontal floor by pulling on a rope attached to the crate at an angle of 30° to the horizontal. The crate weighs 50 kg and the coefficient of kinetic friction between the crate and the floor is 0.65. Find the tension exerted on the rope. **[10]**

(b) A horizontal spring with a force constant k of 1300 Nm^{-1} attached to a wall is connected to a 3 kg mass resting on a frictionless surface. The mass is pulled a distance of 2.5 cm and released. Calculate:

   i) The frequency of oscillation
   ii) The maximum speed of the mass
   iii) The maximum acceleration of the mass
   iv) The speed of the mass when the spring is compressed by 1 cm. **[10]**

Q.8 (a) A small sphere of mass 0.5 g is suspended by a string 50 cm long, with the string kept taut, the ball is whirled in a horizontal circle of radius 25 cm. Calculate its angular speed in radians per second. **[10]**
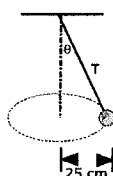
(b) A piece of wood of volume 0.6 m^3 floats in water. Find the volume of the wood outside the water. What additional force is required to immerse it completely under water. The density of the wood is 600 kg/m^3. **[10]**

END OF EXAMINATION

Some Useful Equations

Uniformly accelerated motion:

$$x = \bar{v}t \qquad \bar{v} = \tfrac{1}{2}\left(v_f + v_i\right) \qquad v_f = v_i + at \qquad v_f^2 = v_i^2 + 2ax \qquad x = v_i t + \tfrac{1}{2}at^2$$

Projectile motion:

$$v_x = v_i \cos\theta_i = \text{constant} \qquad v_y = v_i \sin\theta_i - gt \qquad y = \left(v_i \sin\theta_i\right)t - \tfrac{1}{2}gt^2$$

$$y = \left(\tan\theta_i\right)x - \left[\frac{g}{2v_i^2\left(\cos^2\theta_i\right)}\right]x^2 \qquad R = \frac{v_i^2}{g}\sin 2\theta \qquad t = \frac{2v_i \sin\theta}{g}$$

Force and motion:

$$F = ma \qquad w = mg \qquad F_{AB} = -F_{BA} \qquad F_f = \mu F_N$$

Energy:

$$PE = wh = mgh \qquad KE = \tfrac{1}{2}mv^2 \qquad W = Fx\cos\theta \qquad P = \frac{W}{t} = Fv\cos\theta$$

Linear momentum:

$$p = mv \qquad F\Delta t = \Delta mv$$

Circular motion and gravitation:

$$T = \frac{2\pi r}{v} \qquad a_c = \frac{v^2}{r} \qquad F_c = \frac{mv^2}{r} \qquad F_{grav} = G\frac{m_A m_B}{r^2} \qquad 1\,rev = 360^0 = 2\pi\,rad$$

Rotational motion and angular momentum:

$$\theta = \frac{s}{r} = \left(\frac{\omega_i + \omega_f}{2}\right)t \qquad \omega = \frac{\theta}{t} \qquad \theta = \omega_i t + \tfrac{1}{2}\alpha t^2 \qquad \omega_f = \omega_i + \alpha t$$

$$v = \omega r \qquad \omega_f^2 = \omega_i^2 + 2\alpha\theta \qquad \alpha = \frac{\Delta\omega}{\Delta t} = \frac{a_T}{r} \qquad I = \sum mr^2 \qquad I = mk^2$$

$$KE_{rot} = \tfrac{1}{2}I\omega^2 \qquad \tau = FL = I\alpha \qquad W = \tau\theta \qquad P = \tau\omega \qquad L = I\omega$$

Properties of matter:

$$\rho = \frac{m}{V} \qquad F = -kx \qquad \frac{\Delta L}{L_i} = \frac{1}{Y}\frac{F}{A} \qquad \phi = \frac{s}{d} = \frac{1}{s}\frac{F}{A} \qquad B = -\frac{\Delta P}{\Delta V / V_0}$$

$$W_{app} = W\left(1 - \frac{\rho_{fluid}}{\rho}\right) \qquad F_B = \rho V g \text{, submerged object} \qquad F_B = Mg \text{ floating } M$$

Thermal Properties of matter:

$$PV = nRT : \quad \Delta Q = mc\Delta T = nC\Delta T : \quad \Delta L = \alpha L\Delta T : \quad L_t = L_0(1 + \alpha t) : \quad \Delta V = \gamma V\Delta T :$$

$$\Delta W = P\Delta V$$

$$(\Delta Q / \Delta t) = (kA\Delta T) / \Delta L \qquad \Delta Q = \Delta U + \Delta W$$

Thermodynamics:

$$\Delta Q = \Delta U + \Delta W : \quad P_1 V_1^\gamma = P_2 V_2^\gamma \quad PV = nRT \quad W = p.\Delta V$$

$$COP_{ref} = \frac{Q_C}{W} \qquad COP_{heat\,pump} = \frac{Q_H}{W}$$

$$e = 1 - \frac{T_c}{T_h}$$

Waves and Sound:

$$f = \frac{1}{\tau} \qquad v = \pm\sqrt{\frac{k}{m}(x_0^2 - x^2)} \qquad v = \sqrt{\frac{T}{m/L}} \qquad \tau = \frac{1}{f} = 2\pi\sqrt{\frac{m}{k}} \qquad a = -\left(\frac{k}{m}\right)x \qquad v = \sqrt{\frac{Y}{\rho}}$$

$$v = \sqrt{\frac{B}{\rho}} \qquad f' = f\frac{v \pm v_L}{v \mp v_S} \qquad \text{(dB)} = 10.\log\frac{I}{I_0}$$

Volume of a sphere $= (4/3)\pi r^3$; Surface area of a sphere $= 4\pi r^2$

The University of Zambia

School of Natural Sciences

Department of Physics

2014-15 Academic Year

End of Year University Examinations

PHY2112: Magnetism in Matter and Atomic Physics

Attempt <u>any five</u> questions. All questions carry equal marks. The marks are shown in brackets.

Time: Three hours. [Maximum marks = 100.]

Write clearly your computer number on the answer book.

===

Below is a table of constants that might be useful.

Acceleration due to gravity $g = 9.8$ m/s^2	Avogadro's number $N_{Av.} = 6.023 \times 10^{23}$ per mole
electron charge $e = -1.6 \times 10^{19}$C	Electron volt $1eV = 1.6 \times 10^{-19}$J
Permeability of free space $\mu_0 = 4\pi \times 10^7$ T.m/A	Permitivity of free space $\epsilon_0 = 8.85 \times 10^{12}$C^2/N.m^2
Electron mass $m_e = 9.1 \times 10^{-31}$kg	Neutron mass $m_n = 1.00897$amu
$1amu = 1.66 \times 10^{-27}$kg $= 931$ MeV	Planck's constant $h = 6.63 \times 10^{-34}$ J.s
Electron mass $m_e = 9.11 \times 10^{-31}$kg $= 0.511$MeV	Proton mass $m_p = 1.00758$amu
Wien's constant $b = 2.9 \times 10^{-3}$m.K	Stefans constant $\sigma = 5.67 \times 10^{-8}$Wm^{-2}K^{-4}
Boltzmann constant $\kappa = 1.38 \times 10^{-23}$J.K^{-1}	$1\mathring{A} = 10^{-10}$ m. $1nm = 10^{-9}$ m.
Rydberg constant $R = 1.0974 \times 10^7$m^{-1}	speed of light $c = 3 \times 10^8$m/s
Atomic number Cobalt $Z = 27$	converting year to second $1\text{yr} = 31557600 \approx 3.16 \times 10^7$s

Below is a list of formulas that might be helpful.

Faraday's law: $\epsilon = -N\frac{d\Phi_m}{dt}$

  Magnetic flux: $\Phi_m = \int \mathbf{B} \cdot d\mathbf{A}$

  Motional emf: $\epsilon = -Blv$

  Magnetic field inside solenoid : $\frac{\mu_0 NI}{l}$

  Magnetic energy density : $U^* = \frac{U}{V} = \frac{1}{2\mu_0}B^2$

  Decay law: $N = N_0 e^{-\lambda t}$. The decay rate or activity $A = \frac{dN}{dt} = -\lambda N$

  Energy of a photon $E = \frac{hc}{\lambda}$, and momentum of a photon $p = \frac{h}{\lambda}$

  Absorbed intensity $I = I_0 e^{-\mu x}$

  Rydberg equation:

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

  Planck's formula:

$$\Psi_\lambda d\lambda = \frac{8\pi ch\lambda^{-5}}{e^{ch/\lambda\kappa T} - 1}d\lambda$$

  Photoelectric equation: $\frac{1}{2}mv^2 = h\nu - \varphi$

  Compton scattering equation: $\Delta\lambda = \lambda' - \lambda = \frac{h}{m_0 c}(1 - \cos\theta)$

  Moseley's law: $\sqrt{\nu} = a(Z - b)$

  Wien's displacement law: $\lambda_{max}T = 0.2898 \times 10^{-2}$ m.K

  De Broglie wavelength: $\lambda = \frac{h}{mv}$

  Total energy of a planetary electron

$$E_n = E_k + E_p = \frac{1}{2}mv^2 - \frac{Ze^2}{4\pi\epsilon_0 r}$$

  Permitted radii in Bohr atom:

$$r = \frac{\epsilon_0 h^2 n^2}{\pi m_e Ze^2}$$

Q1 (a) Show that the magnetic field intensity **B**, the magnetization **M** and the magnetic field strength **H** are related by $\mathbf{B} = \mu_0\,(\mathbf{H} + \mathbf{M})$ [9]

(b) Show that the magnetic permeability μ and the susceptibility χ_m are related by $\mu = \mu_0(1 + \chi_m)$, where μ_0 is permeability of free space. [4]

(c) A toroidal winding carrying a current of 5 amps is wound with 60 turns/m of wire. The core is made from iron having a permeability of 5000. Find **H** and **B** inside the iron core. [4]

(d) Differentiate between paramagnetic and diamagnetic materials. [3]

[Total 20 Marks]

Q2 (a) X-rays from a certain cobalt target tube is composed of the strong K-series of cobalt and two week K- lines due to impurities. The wavelength of the K_α lines is $1.785\dot{A}$ for cobalt and for the impurities are $2.285\dot{A}$ and $1.537\dot{A}$. Using Moseley's law , calculate the atomic number of each of the two impurities. [7]

(b) The K absorption edge of tungsten is $0.178\dot{A}$ and the average wavelength of the K-series lines are $K_\alpha = 0.210\dot{A}$, $K_\beta = 0.184\dot{A}$, and $K_\gamma = 0.179\dot{A}$.

(i) Construct the X-ray energy level of the diagram for tungsten. [6]

(ii) What is the least energy required to excite the $L-$series? [2]

(iii) What is the wavelength of the L_α line? [2]

(iv) If a 100KeV electron struck the tungsten target in a tube, what is the shortest x-ray wavelength it could produce? [3]

[Total 20 Marks]

4

Q3 (a) A metal surface is illuminated by light of frequency 0.90×10^{15}/s emits electrons which can be stopped by a retarding potential of 0.60 volts. When the same surface is illuminated by light of frequency 1.26×10^{15}/s, the required retarding potential is 2.1 volts. Using these data, deduce a value of Planck's constant and the work function of the metal. [8]

(b) A beam of electrons bombards a sample of hydrogen. Through what potential difference must the electrons be accelerated if the first line of the Balmer series is to be emitted? [4]

(c) A 2MeV photon causes the emission of a Compton electron and scatters at an angle of $90°$ from its path

(i) What is the wavelength of the scattered photons? [4]

(ii) What is the energy of the Compton electron? [4]

[Total 20 Marks]

Q4 (a) (i) In Bohr's original theory of the hydrogen atom (circular orbits), what postulate led to the choice of the allowed energy levels? [3]

(ii) Later de Broglie pointed out a most interesting relationship between the Bohr postulate and the de Broglie wavelength of the electron. State and derive this relationship. [4]

(b) In radio astronomy, hydrogen atoms are observed in which radiative transitions from $n = 109$ to $n = 108$ occur. What are the frequency and wavelength of the radiation emitted in this transition? [5]

(c) Using the Bohr model of the atom, show that an expression for the energy levels of the He^+ ion is

$$E_n = -\frac{2me^4}{(4\pi\epsilon_0)^2 n^2 \hbar^2}$$

where $\hbar = h/2\pi$ [8]

[Total 20 Marks]

5

Q5 (a) The figure below shows a U-shaped conducting rail that is oriented vertically in a magnetic field. The rail has no electric resistance and does not move. A slide wire with mass M and resistance R can slide up and down without friction while maintaining electric contact with the rail. The slide wire is released from rest.
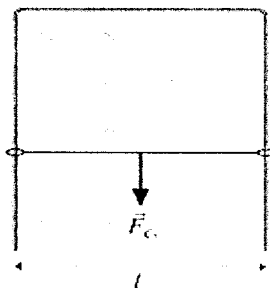
(i) Show that the slide wire reaches a terminal speed v_{term} given by

$$v_{term} = \frac{mgR}{B^2 l^2}$$

[8]

(ii) Determine the value of v_{term}, if $l = 20$ cm, $m = 10$ g, $R = 0.10$ Ω and $B = 0.5$ T. [2]

(b) A flat loop of wire is placed in a region where the magnetic field is perpendicular to the plane of the loop. The magnitude of **B** varies in time according to the expression $B = B_0 e^{-at}$, where a is some constant. Find the induced emf in the loop as a function of time. [4]

(c) An ideal air-core solenoid has a radius 2.0 cm, length 12 cm, and 9000 turns. The solenoid caries a current of 2.0 A.

(i) Find the magnetic field inside the solenoid. [2]

(ii) How much energy U is stored in the solenoid? [4]

[Total 20 Marks]

6

Q6 (a) (i) The equation for transmitted intensity is $I = I_0 e^{-\mu x}$, where μ is the linear attenuation coefficient. Define and obtain the expression for **"half-value"** layer as understood in X-ray absorption. [3]

(ii) How many "half-value" layers are necessary to reduce the intensity of an x-ray beam to $\frac{1}{16}$ of its incident value? [3]

(b) The linear absorption coefficient of aluminum and copper are $0.693\,\text{cm}^{-1}$ and 13.9cm^{-1}, respectively, for the K_α line from tungsten

(i) What percentage of the intensity of this line will be absorbed by 5mm plate of aluminum? [3]

(ii) What thickness of aluminum is equivalent to the absorption of 5mm of copper for this line? [5]

(c) In Uranium $Z = 92$ the K absorption edge is $0.0107\,\mathring{A}$ and the K_α line is $0.126\,\mathring{A}$. Determine the wavelength of the L absorption age. [6]

[Total 20 Marks]

Q7 (a) State the differences between natural and artificial radioactivities. [2]

(b) (i) The activity of a certain radio-nuclide decreases by 15% its original value in 10 days. Find the disintegration constant and half-life. [4]

(ii) The half-life of the radioactive substance is 15 years. Calculate the period in which 2.5% of the initial quantity will have decayed. [5]

(c) The decay law is stated as $N = N_0 e^{-\lambda t}$. Explain the meaning of all symbols appearing in this equation. Hence show that the activity, A, can be written as $A = \lambda N$. [4]

(d) A photon has a wavelength of 2.3×10^{-7}m. Calculate the energy of the photon in eV and the momentum of the photon. [5]

[Total 20 Marks]

==End of PHY2112 Examination==

THE UNIVERSITY OF ZAMBIA
SCHOOL OF NATURAL SCIENCES
DEPARTMENT OF PHYSICS

2014/15 ACADEMIC YEAR

END YEAR UNIVERSITY EXAMINATIONS

PHY-2522: ANALYTICAL MECHANICS AND SPECIAL THEORY OF RELATIVITY

Time allowed: 3 Hours

Instructions

- This examination paper contains 7 questions. Each question carries 20 marks. Attempt any 5 questions out of the 7 questions given.

- This paper has a total of 100 marks. All questions carry equal marks

- Show all your working clearly. Omission of essential work will result in loss of marks

- Write your computer number clearly on the answer sheets

Where necessary, you may use the following:

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_k}\right) - \frac{\partial L}{\partial q_k} = Q_k, \quad \dot{q}_k = \frac{\partial H}{\partial p_k}, \quad \frac{\partial H}{\partial t} = -\frac{\partial L}{\partial t}, \quad -\dot{p}_k = \frac{\partial H}{\partial q_k}, \quad x' = \gamma(x - vt),$$

$$t' = \gamma\left(t - \frac{Vx}{c^2}\right), \quad y' = y, \quad z' = z, \quad \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}, \text{ speed of light } c = 3 \times 10^8 \, \text{m/s}$$

$$\frac{\partial^2 u(x,t)}{\partial t^2} = \frac{T}{\mu}\frac{\partial^2 u(x,t)}{\partial x^2}, \quad \gamma L = L_0, \quad I_{sphere} = \frac{2}{5}Ma^2$$

$$A_n = \frac{2}{L}\int_0^L u_0(x)\sin\left(\frac{n\pi x}{L}\right)dx, \quad B_n = \int_0^L \dot{u}_0(x)\sin\left(\frac{n\pi x}{L}\right)dx,$$

$$\int \frac{dx}{\sqrt{\alpha^2 - x^2}} = \sin^{-1}\left(\frac{x}{\alpha}\right) = -\cos^{-1}\left(\frac{x}{\alpha}\right), \quad \int x\sin ax = \frac{\sin ax}{a^2} - \frac{x\cos ax}{a}, \quad \int x\cos ax = \frac{\cos ax}{a^2} + \frac{x\sin ax}{a}$$

1

Q1 Two springs of spring constant K_1 and K_2 are initially in configuration shown in the figure below A block of wood of length L and mass M is then inserted in the middle between the free ends of the spring and placed on rollers so that it moves freely without any friction. Assume $K_1 > K_2$.
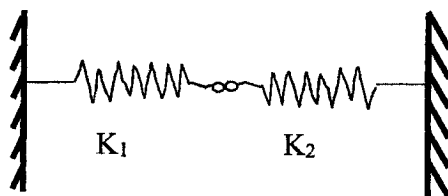
(a) Sketch a free body diagram of the block when inserted between the springs and indicate all the forces acting on it. **[3 marks]**

(b) Using Lagrange's mechanics, show that the equation of motion for the block can be written as

$$M\ddot{X} + (K_1 + K_2)X + \frac{L}{2}(K_2 - K_1) = 0.$$ **[15 marks]**

(c) Write down the expression for the natural frequency of the wooden block. **[2 marks]**

Q2 Two particles P_1 and P_2 of masses m_1 and m_2 connected by a massless inextensible rod of length a as shown in the figure below are allowed to move freely. P_1 can only move horizontally in a frictionless tube while P_2 can swing in the xy-plane below the line OA.
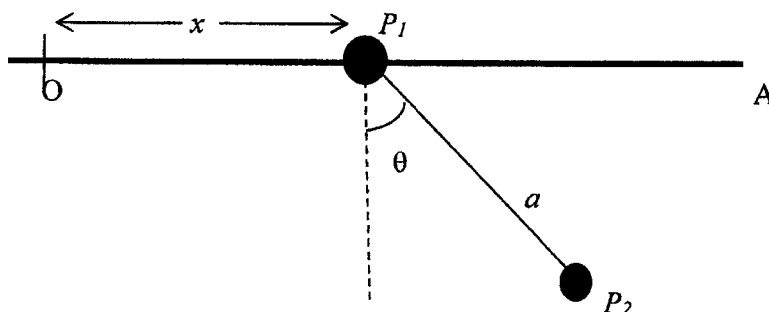
(a) Write down the position vector of P_1 with respect to O at any time t,   **[1 mark]**

(b) write down the position vector of P_2 with respect to O at any time t,   **[2 marks]**

(c) obtain the expression for the total kinetic energy of the system,   **[11 marks]**

(d) obtain the expression for the total potential energy of the system and   **[2 marks]**

(e) write down the expression for Lagrangian of the system.   **[4 marks]**

2

Q3 A spring of force constant 6.4 N/m hangs vertically. A body of mass 0.4 kg is attached to its free end. It is raised 2 cm from its equilibrium position and released. The subsequent motion is opposed by a frictional force with a damping constant of 4 N/m.

  (a) Write down explicitly the differential equation of motion for the body,   [2 marks]

  (b) determine whether the motion of the body is oscillatory and   [8 marks]

  (c) determine the position of the body at time t seconds after release.   [10 marks]

Q4(a) The solution for the motion of a particle undergoing simple harmonic motion is given as

$$x = A\sin\left(\omega_0 t + \delta\right).$$

The particle has a velocity v_1 when the displacement is x_1 and a velocity v_2 when the displacement is x_2. Find the

  (i) angular frequency and   [10 marks]

  (ii) amplitude of the motion in terms of the given quantities.   [6 marks]

  (b) The equation of motion of a damped harmonic oscillator is given as

$$\ddot{x} + k\dot{x} + \omega^2 x = 0.$$

Assuming a solution of the form $x = e^{\lambda t}$, show that the general solution may be written as

$$x = Ae^{\frac{-k+\sqrt{k^2-4\omega^2}}{2}t} + Be^{\frac{-k-\sqrt{k^2-4\omega^2}}{2}t}$$

where A and B are arbitrary constants.   [4 marks]

Q5(a) The relativistic expression for the kinetic energy of a moving particle is given by

$$T = mc^2 - m_0 c^2$$

Show that for velocities v much lower than the speed of light c, this expression reduces to the Newtonian one.   [7 marks]

(b) Given that

$$x' = \gamma(x - vt), \quad t' = \gamma\left(t - \frac{Vx}{c^2}\right), \quad y' = y, \quad z' = z$$

where the symbols have their usual meanings in the special theory of relativity, show that the composition of velocity in the laboratory frame for the x – component is

$$u_x = \frac{v'_x + V}{1 + \dfrac{V}{c^2}u'_x} \qquad\qquad \textbf{[7 marks]}$$

(c) Using the Galilean transformations

$$x'_1 = x_1 - vt, \quad x'_2 = x_2, \quad x'_3 = x_3, \quad t' = t,$$

show that Newton's second law of motion for a particle of mass m is invariant in a stationary inertial frame S and an inertial frame S' moving with a constant velocity v with respect to frame S. **[6 marks]**

Q6 By solving the boundary value problem

$$\frac{\partial^2 y}{\partial t^2} = c^2 \frac{\partial^2 y}{\partial x^2},$$

find the general expression which represents the nth normal modes of vibration of a string of length L with fixed endpoints if the string is initially given a displacement $f(x)$ from its equilibrium position and then released. **[20 marks]**

Q7 A particle of mass m is attracted toward a given point by a force of magnitude

$$\left|\vec{F}(r)\right| = \frac{b}{r^2}$$

where b is a positive constant. Using Cartesian coordinates,

(a) show that the Hamiltonian is

$$H(x,y,p_x,p_y) = \frac{1}{2}m\left(\frac{p_x^2}{m^2} + \frac{p_y^2}{m^2}\right) + \frac{b}{\sqrt{x^2 + y^2}}, \qquad \textbf{[12 marks]}$$

and

(b) that the equations of motion are

$$m\ddot{x} + \frac{bx}{\left(x^2 + y^2\right)^{3/2}} = 0$$

[4 marks]

and

$$m\ddot{y} + \frac{by}{\left(x^2 + y^2\right)^{3/2}} = 0$$

[4 marks]

**************END OF PHY 2522 EXAMINATION*****************

The University of Zambia
School of Natural Sciences
Department of Physics
2014/15 Academic Year
End of Year University Examinations
PHY2712: Optics

Answer **QUESTION ONE (1)** and <u>any other four</u> questions. All questions carry equal marks. The marks are shown in brackets.

Time: Three (3) hours.   **Maximum marks = 100.**

Write clearly your computer number on the answer book. Show your working clearly. Omission of essential work will lead to loss of marks.

===

Physical Constants

- Acceleration due to gravity $g = 9.80665$ m.s^{-2} ,

- Universal gas constant $R = 8.314$ J/mole.K,

- Density of mercury, $\rho_{mercury} = 13600$ kg/m^3 ,

- Density of water, $\rho_{water} = 1000$ kg/m^3 ,

- Specific heat capacity of oil is 1450J/kg.K ,

- Stefan Boltzmann constant is $\sigma = 5.672 \times 10^{-8}$ Wm^{-2}K^{-4} ,

- Planck's constant $h = 6.6261 \times 10^{-34}$ J.s ,

- Boltzmann's constant $k = 1.38066 \times 10^{-23}$ J/K

- Speed of light in vacuum $c = 2.9979 \times 10^8$ m/s .

- Permittivity of free space $\varepsilon_0 = 8.854187 \times 10^{-12}$ F/m

- Specific heat capacity of water $c_w = 4184$ J/kg.K

FORMULAE THAT MAY BE USEFUL

Speed of light	$c = \lambda f$
Energy of a photon with frequency f	$E = hf$
Optical path length	$L_{op} = nd = ct$
Optical path length in a medium of continuous refractive index	$L_{op} = \int_C nds$
Snell's law	$n_i \sin\theta_i = n_r \sin\theta_r$
Fermat's Principle	$\delta \int\limits_{\substack{A \to B \\ C}} nds = 0$
Numerical Aperture	$N_A = n\sin\theta_{max} = \left[n_h^2 - n_l^2 \right]^{\frac{1}{2}}$
Optical path invariant in a medium where $n = n(z)$	$\beta = n(z)\cos\left(\theta(z)\right)$
General one dimensional ray equation, where $n = n(z)$	$\dfrac{d^2 z}{dx^2} = \dfrac{1}{2\beta^2}\dfrac{dn^2}{dz}$
The mirror equation under paraxial ray approximation	$\dfrac{1}{x_i} + \dfrac{1}{x_o} = \dfrac{2}{R} = \dfrac{1}{f}$
Gauss relation for a single spherical surface	$\dfrac{n_2 - n_1}{R} = \dfrac{n_2}{x_i} - \dfrac{n_1}{x_o}$
The Lens maker's equation	$\dfrac{1}{f} = \left[\dfrac{n_2}{n_1} - 1 \right]\left[\dfrac{1}{R_1} - \dfrac{1}{R_2} \right]$
Newton's lens equation	$x_1 x_2 = f^2$
Electrostatic force	$\mathbf{F} = q\mathbf{E}$
Polarisation	$\mathbf{P} = \chi\mathbf{E}$
Relative permittivity	$\varepsilon_r(\omega) = n^2$
Electric susceptibility	$\chi = \varepsilon_0 \left[\varepsilon_r(\omega) - 1 \right] = \varepsilon_0 \left[n^2 - 1 \right]$
Stefan-Boltzmann law	$I = \varepsilon\sigma T^4$
Wein's displacement law	$\lambda_m T = 2898\,\mu\text{m-K}$

Normalised frequency	$V = \dfrac{2\pi a}{\lambda}[N_A] = \dfrac{\pi d}{\lambda}[N_A]$
Maximum number of modes supported by an SI fibre	$M_N \cong \dfrac{1}{2}V^2$
Maximum number of modes supported by a GRIN fibre	$M_N \cong \dfrac{1}{2}V^4$
Signal attenuation coefficient	$\alpha = \dfrac{10}{L}\log_{10}\left(\dfrac{P_i}{P_o}\right)$

The Binomial Expansion

If $|x| < 1$, then for all values of the power n we have

$$[1+x]^n = 1 + nx + \frac{n[n-1]}{2!}x^2 + \frac{n[n-1][n-2]}{3!}x^3 + \frac{n[n-1][n-2][n-3]}{4!}x^4 + \ldots\ldots$$

where, $n! = n[n-1][n][n-3]\ldots\ldots\times 4\times 3\times 2\times 1$ and with the definition $0! = 1$. Thus for $|x| << 1$,

then terms with higher powers of x may be neglected to get

$$[1+x]^n \approx 1 + nx,$$

and $\quad [1-x]^n \approx 1 - nx$

In particular, for $|x| << 1$ and $n = -1$ we have
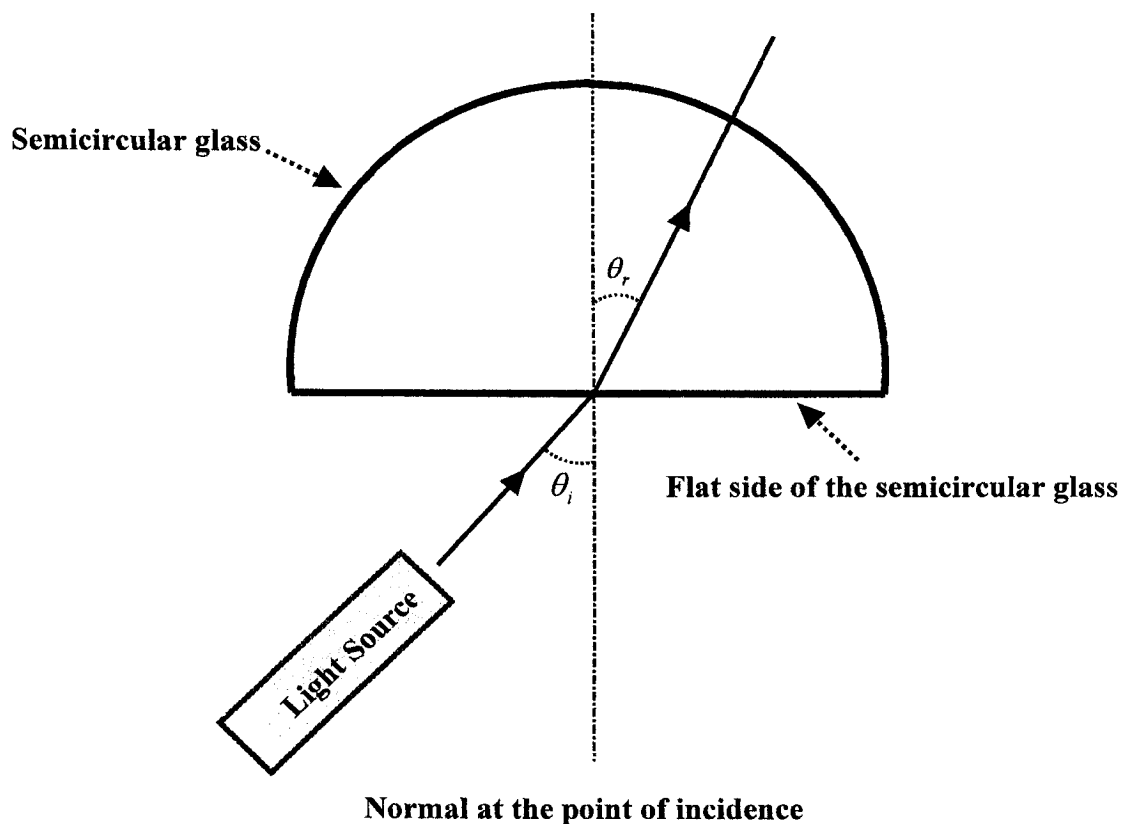
$$[1-x]^{-1} \approx 1 + x.$$

STATISTICAL FORMULAE

Arithmetic mean $\bar{x}$ (or expectation value $\langle x \rangle$) for a set of N data points x_i where $i = 1, 2, 3, ..., N$	$\bar{x} = \langle x \rangle = \dfrac{1}{N}\sum\limits_{i=1}^{N} x_i$
Deviation X_i of the ith data point from the mean $\bar{x}$	$X_i = x_i - \bar{x}$
Sum of deviations of the ith data point from the mean $\bar{x}$	$\sum\limits_{i=1}^{N} X_i = \sum\limits_{i=1}^{N}[x_i - \bar{x}] = 0$
Sample variance σ^2	$\sigma^2 = \begin{cases} \dfrac{1}{N-1}\sum\limits_{i=1}^{N} X_i^2 \\ \dfrac{S_{XX}}{N-1} \end{cases}$
Sample standard deviation σ	$\sigma = \begin{cases} \sqrt{\dfrac{1}{N-1}\sum\limits_{i=1}^{N} X_i^2} \\ \sqrt{\dfrac{S_{XX}}{N-1}} \end{cases}$
Standard error ε	$\varepsilon = \pm\dfrac{\sigma}{\sqrt{N}}$
Pearson's correlation coefficient r	$r = \begin{cases} \dfrac{1}{[N-1]\sigma_x\sigma_y}\sum\limits_{i=1}^{N} X_iY_i \\ \dfrac{S_{XY}}{[N-1]\sigma_x\sigma_y} \end{cases}$
Coefficient of determination r^2	$r^2 = \left[\dfrac{\sum\limits_{i=1}^{N} X_iY_i}{[N-1]\sigma_x\sigma_y}\right]^2 = \left[\dfrac{S_{XY}}{[N-1]\sigma_x\sigma_y}\right]^2$
Gradient a_1 of the graph of best fit straight line	$a_1 = r\dfrac{\sigma_y}{\sigma_x}$
Intercept a_0 of the best fit straight line	$a_0 = \bar{y} - \bar{x}a_1$
Equation of best fit line is	$y = a_0 + a_1 x$

1. Figure 1 shows the experimental arrangement that was used to determine the refractive index for the material of a semicircular glass placed in air using Snell's law.

If n_a and n are refractive indices for media 1 and 2 respectively, then Snell's law states that for a ray passing from medium 1 into 2, we have

$$n_a \sin \theta_i = n \sin \theta_r .$$

Semicircular glass

θ_r

Flat side of the semicircular glass

θ_i

Light Source

Normal at the point of incidence

Note that refraction of the light ray takes place only on the flat side of the semi-circular lens. In the special case when the surrounding medium is air, we have $n_a = 1.00$ yielding

$$\sin \theta_i = n \sin \theta_r ,$$

implying that we should have a linear relation between $\sin \theta_i$ and $\sin \theta_r$. Table 1 shows the data for θ_i and θ_r that were obtained from the experiment.

Table 1: Experimental data collected for θ_i and θ_r

θ_i [degrees]	θ_r [degrees]	$\sin\theta_i$	$\sin\theta_r$	$n = \dfrac{\sin\theta_i}{\sin\theta_r}$
21.000	14.000	0.358	0.242	1.481
30.000	19.000			
46.000	29.000			
52.000	33.000			

(a) Copy and complete all entries in table 1. **[1 mark]**

(b) Plot the graph of $\sin\theta_i$ against $\sin\theta_r$. **[2 marks]**

(c) Conduct a two-axis regression analysis and show that the best-fit equation for the data in table 1 is given by

$$\sin\theta_i = 1.41\sin\theta_r + 0.028.$$ **[13 marks]**

(d) Use the best-fit equation in (c) to draw the best-fit line for graph of $\sin\theta_r$ against $\sin\theta_i$ in (b). **[1 mark]**

(e) What is the refractive index of the material of the glass? **[1 mark]**

(f) Why was there no refraction at the circular surface of the glass? **[1 mark]**

(g) Write a conclusion for this experiment. **[2 marks]**

2. (a) A step index fibre in air has a numerical aperture of 0.18, a core refractive index of 1.50 and a core diameter of $60\mu m$. Monochromatic light at a wavelength of $0.8\mu m$ is transmitted through the fibre. Calculate the

   (i) normalized frequency for the fibre, **[4 marks]**

   (ii) number of modes in the cable, **[2 marks]**

   (iii) refractive index of the cladding. **[5 marks]**

(b) Optical power of $3.20mW$ is launched into an optical fibre of length $110m$. If the power emerging from the other end of the fibre is $1.25mW$, calculate the fibre attenuation coefficient. **[5 marks]**

(c) Give two major advantages of using optical fibres over conducting wires. **[4 marks]**

3. (a) The eye can be regarded as a single spherical refracting surface of radius of curvature 7.7mm, separating two media of refracting indices 1.00 and 1.34. Calculate the distance from the refracting surface at which a parallel beam of light will come to focus. **[5 marks]**

(b) Two thin convex lenses of focal length f_1 and f_2 are coaxial and separated by a finite distance d in air. Show that, under paraxial ray approximation, the equivalent focal length f is given by the relation

$$f = \frac{f_1 f_2}{f_1 + f_2 - d}.$$

[15 marks]

[Include a clearly labeled ray diagram to support your derivation]

4. (a) A rod of length 11.5cm lies along the principal axis of a concave mirror of focal length 11.5cm in such a way that the end of the rod that is close to the Pole of the concave mirror is 23.0cm away from it. Find the length of the image. **[10 marks]**

23.0 cm

Rod
A   B

11.5 cm
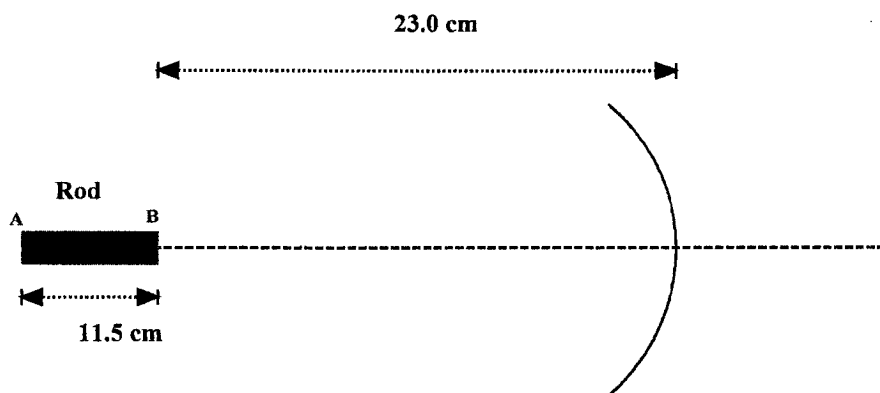
(b) While sitting in a stationary car, a driver notices a jogger running towards the car using aside view (convex) mirror of radius of curvature $R = 2.0\text{m}$. If the jogger is running at a speed of 4.1m/s, how fast does the image of the jogger appear to move when the jogger is 39.0m away? **[10 marks]**

5. (a) (i) Show that, in the case of a spherical concentrator, the contour of the spherical reflector y is related to the radius of curvature R and angle α of incidence of a ray as

$$y = \left[\frac{1}{R[1+\cos\alpha]} \right] x^2 ,$$

where x and y are horizontal and vertical distances, respectively, from the circle center. **[9 marks]**

(ii) Hence, or otherwise, show that as $\alpha \to 0$, the contour of the spherical reflector becomes parabolic with focus $f = R/2$. **[1 mark]**

(b) Prove that, for a refracting surface of refractive index n_2, the longitudinal magnification L is related to the lateral magnification m by

$$L = \left[\frac{n_2}{n_1} \right] m^2 ,$$ **[10 marks]**

6. From the electron theory of dispersion, the net force acting on an electron due to the application of an electric field $\mathbf{E}$ obeys the relation

$$m\frac{d^2\mathbf{x}}{dt^2} + \gamma\frac{d\mathbf{x}}{dt} + k\mathbf{x} = q\mathbf{E} ,$$

where m is the mass of an electron, $\mathbf{x}$ is the displacement of an electron, q is the electron charge, γ is the damping constant, k is the force constant, while t is time.

Consider a time dependent oscillating electric field $\mathbf{E}$ of the form

$$\mathbf{E} = \mathbf{E}_{max} e^{i\omega t} ,$$

where $\mathbf{E}_{max}$ is the amplitude of $\mathbf{E}$ while ω is the frequency of the incident light.

(a) Show that the refractive index n of a medium with one resonance frequency ω_0 is given by

$$n^2 = \frac{Nq^2}{m_e \varepsilon_0 \left[\omega_0^2 - \omega^2 \right] + i\gamma\omega} + 1 \, .$$

Here N = the number of dispersion electrons per unit volume, q = the charge of an electron, c = speed of light in a vacuum, m = mass of an electron, a while ε_0 is the permittivity of free space. **[12 marks]**

(b) Hence, or otherwise, show that in the case of a transparent medium and for $\omega_0 \gg \omega$, the refractive index can be expressed in terms of the Cauchy dispersion relation, namely

$$n = 1 + A + \frac{B}{\lambda^2} \, ,$$

where $A = \dfrac{Nq^2 f_1}{2m\varepsilon_0 \omega_0^2}$ and $B = \dfrac{Nq^2 f_1^2 \omega^2}{2m\varepsilon_0 \omega_1^4}$,

are the Cauchy dispersion constants while f_1 = the number of dispersion electrons per unit volume oscillating with natural frequency ω_0 .

[Note: The Binomial expansion is provided on page 3 for your convenience]

[8 marks]

7.   The refractive index of a material varies according to

$$n^2(z) = n_1^2 - \gamma^2 z^2 \, ,$$

where γ is a constant while z is the radial distance from the centre of the centre, while n_1 is the refractive index when $z = 0$. If β is the optical path invariant, while x is the length of material from the section where light s incident on it along its centre, show that the ray path is sinusoidal and given by

$$z = \left[A_1 + A_2 \right] \cos\left(\frac{\gamma}{\beta} x \right) + \left[\left[A_1 - A_2 \right] \sin\left(\frac{\gamma}{\beta} x \right) \right] i \, ,$$

where $i = \sqrt{-1}$ while A_1 and A_2 are arbitrary constants. **[20 marks]**

[Hint: You may use a trial solution of the form $z = Ae^{kx}$]

--------- END OF PHY2712 EXAM 2015 ---------

The University of Zambia
School of Natural Sciences
Physics Department
University Examinations 2015
PHY4132: Theoretical Nuclear Physics

Attempt **any four** questions. All questions carry equal marks. The marks are shown in brackets. Clearly indicate on the answer script cover page which questions you have attempted.

Time: Three hours.   **Maximum marks = 100.**

Write your computer number clearly on the answer book.

Wherever necessary use:

$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N.m^2	$m_{hydrogen\ atom} = 1.007825$ a.m.u.
$m_{neutron} = 1.008665$ a.m.u. $= 939.551$ MeV	$m_{alpha} = 4.002603$ a.m.u.
1 a.m.u. $= 931.5$ MeV $= 1.6604 \times 10^{-27}$ kg	$m_p = 1.67 \times 10^{-27}$ kg $= 938.28$ MeV
$c = 3 \times 10^8$ m/s	$m_e = 9.11 \times 10^{-31}$ kg $= 0.511$ MeV
$h = 6.63 \times 10^{-34}$ J-s	$e = 1.6 \times 10^{-19}$ C
$\hbar = 6.58 \times 10^{-22}$ MeV-s $= 1.05 \times 10^{-34}$ J-s	1eV $= 1.6 \times 10^{-19}$ J
1 fermi $= 10^{-15}$ m	1 barn $= 10^{-28}$ m^2
Avogadro's constant $= 6 \times 10^{23}$ per mole	Velocity of light $= 3 \times 10^8$ m.sec^{-1}.
$\left(e^2 / 4\pi\varepsilon_0\right) = 1.44$ MeV-fermi	$m = \left(m_0 c^2 / c^2\right) \equiv \left(MeV / c^2\right)$
$\tan\left(A+B\right) = \dfrac{\tan A + \tan B}{1 - \tan A \tan B}$	$e^2 / \hbar c = (1/137)$ $\hbar c = 197.33$ MeV-fermi

$\left(1s_{1/2}\right)^2, \left(1p_{3/2}\right)^4, \left(1p_{1/2}\right)^2, \left(1d_{5/2}\right)^6, \left(2s_{1/2}\right)^2, \left(1d_{3/2}\right)^4, \left(1f_{7/2}\right)^8, \left(2p_{3/2}\right)^4, \left(1f_{5/2}\right)^6, \left(2p_{1/2}\right)^2, \left(1g_{9/2}\right)^{10}, [50]$

$E = \dfrac{\hbar^2}{2\Im}\left[J(J+1) - BJ^2(J+1)^2\right]$. $\Delta E_C = \dfrac{3}{5}\dfrac{e^2}{R}\left[Z^2 - (Z+1)^2\right]$

Q1(a) (i) Name the four basic interactions known in nature and give a number characterizing the strength of each interaction.

(ii) Discuss the range of each of these interactions and explain how each one is believed to arise.

(iii) List a few important processes for which each one of these interactions is essential. [9]

(b) Mention the principal types of evidence obtained from nucleon-nucleon interactions which suggest that nuclear forces are: [8]

        i) repulsive at a very short distance

        ii) of short range and attractive

        iii) spin-dependent

        iv) non-central and

        v) charge-independent.

(c) The semi-empirical mass formula for the mass of a neutral atom is

$$M(A,Z) = ZM_H + (A - Z)M_N - \alpha A + \beta A^{2/3} + \gamma \frac{Z^2}{A^{1/3}} + \delta \frac{(A - 2Z)^2}{A} \pm \varepsilon(A,Z),$$

where M_H and M_N are the masses of the hydrogen atom and the neutron respectively in atomic mass units.

What is the origin of each term in the formula? Write short notes. [8]

Q2(a). Explain the concepts of Parity and Symmetry for nuclear wave functions.

What do you understand by parity violation?

How is the parity of a nucleon in a potential determined? [16]

(b) The deuteron $\left({}^2_1H \right)$ has $J = 1\hbar$ and a magnetic moment $\left(\mu = 0.857\mu_N \right)$ which is approximately the sum of the proton and neutron magnetic moments $\left(\mu_p = 2.793\mu_N \right)$ and $\left(\mu_n = -1.913\mu_N \right)$.

(i)From these facts what can you infer concerning the orbital motion and spin alignment of the neutron and proton in the deuteron?

(ii) How might one interpret the lack of exact equality of μ and $(\mu_p + \mu_n)$?

(iii) How can the neutron have a non-zero magnetic moment? [9]

3(a) Explain the meaning of *scattering length*. Explain the significance when it is positive, and when it is negative. [5]

(b) What do you understand by "effective range" in nucleon-nucleon scattering? When is the approximation valid? [4]

(c) The tabulated masses of $^{9}_{3}Li$, $^{9}_{4}Be$, and $^{9}_{5}B$ are 9.0268, 9.0122, and 9.0133 a.m.u. respectively. Calculate in MeV the values of the Coulomb and asymmetry coefficients in the semi-empirical mass formula

$$M(A,Z) = Z M_H + N M_N - \alpha A + \beta A^{2/3} + \frac{\delta (A-2Z)^2}{A} + \frac{\gamma Z^2}{A^{1/3}} + \lambda (A,Z)$$

Given M_H = 1.00783 amu, M_N = 1.00867 amu and 1 amu = 931.5 MeV. [8+8]

Q4. A neutron is bound in the lowest possible state *(l = 0)* to a heavy nucleus. The binding energy is E_B = 20 MeV (E_B = − 20 MeV). The potential acting on the neutron is V_0 = 40 MeV; the radius r_0 of the well is not known :
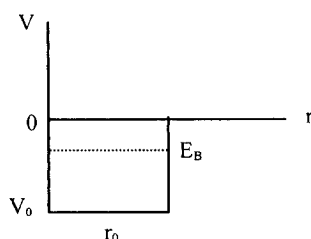
i)   solve the radial wave equation for *l = 0* inside and outside the well, and sketch the wave function *u*

ii) apply boundary conditions at $r = r_0$ to obtain an equation between the pertinent wave numbers and r_0

iii) find the numerical values of the wave numbers and solve the equation mentioned under (ii) for r_0.

(For the reduced mass use *m = 1 a.m.u.*). [8+8+9]

Given, 1 eV = 1.6 × 10^{-19} joules, $\hbar$ = 1.05 × 10^{-34} joules-second = 6.582 × 10^{-22} MeV-second.

c = 3 × 10^8 m/s. Neutron mass = 1.008665 amu. 1 amu = 1.6604 × 10^{-27} kg = 931.15 MeV.

Region I: $E = -E_B$ $V = -V_0$. We have $\dfrac{d^2u}{dr^2} + k_1^2 u = 0$ where $k_1 = \dfrac{\sqrt{2\mu(V_0 - E_B)}}{\hbar}$

Q5(a) (i) Describe briefly the basic assumptions concerning the features of the forces involved in the single-particle shell model of the nucleus.   [6]

(ii) Write down the rules for determination of the angular momenta and parities of nuclear ground states as obtained from the shell model.   [6]

(b) In the nuclear shell model, orbitals are filled in the order

$$1s_{1/2}, 1p_{3/2}, 1p_{1/2}, 1d_{5/2}, 2s_{1/2}, 1d_{3/2} \text{ etc.}$$

(i) What is responsible for the splitting between $p_{3/2}$ and $p_{1/2}$ orbitals?   [3]

(ii) In the model, $^{16}O\,(Z = 8)$ is a good closed-shell nucleus and has spin and parity $J^\pi = 0^+$. What are the predicted J^π values for ^{15}O and ^{17}O?   [4]

(iii) For odd-odd nuclei, a range of J^π values is allowed. What are the allowed values for $^{18}F\,(Z = 9)$?   [3]

(iv) For even-even nuclei (e.g. for ^{18}O), J^π is always 0^+. How is this observation explained?   [3]

Q6(a) Give short explanations of the terms *super allowed, allowed, first forbidden*, and *second forbidden* in beta transitions in terms of (i) the nuclear matrix element $|M_{if}|$, (ii) log fT values and (iii) the nuclear shell model.   [15]

(b) Classify the following beta transitions (the spin-parity, J^π, of the nuclear states are given in brackets):

$$^{14}O \rightarrow {}^{14}N^* + e^+ + \nu \quad \left(0^+ \rightarrow 0^+\right) \qquad {}^6He \rightarrow {}^6Li + e^- + \nu \quad \left(0^+ \rightarrow 1^+\right)$$

Why is the transition

$$^{17}F \rightarrow {}^{17}O + e^- + \nu \quad \left(\frac{5^+}{2} \rightarrow \frac{5^+}{2}\right) \text{ called a } \textit{super-allowed transition?} \quad [10]$$

== **End of PHY4132 Exam** ==